Iron AND Steel ENGINEER

ENGINEERING SERVICE TO THE IRON AND STEEL INDUSTRY SINCE 1907

V. 38 #12

DECEMBER 1961

Elbolift at J & L stacks coils in the warehouse, loads boxcars and flat-bed trucks.

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AUTOMATIC's Elbolift measures only 80" high, yet can stack coils weighing up to 25,000 lbs. as high as 120". Because the truck is narrower than the width of a palletized coil, the truck can stack coils close together, fully utilizing all available storage space.

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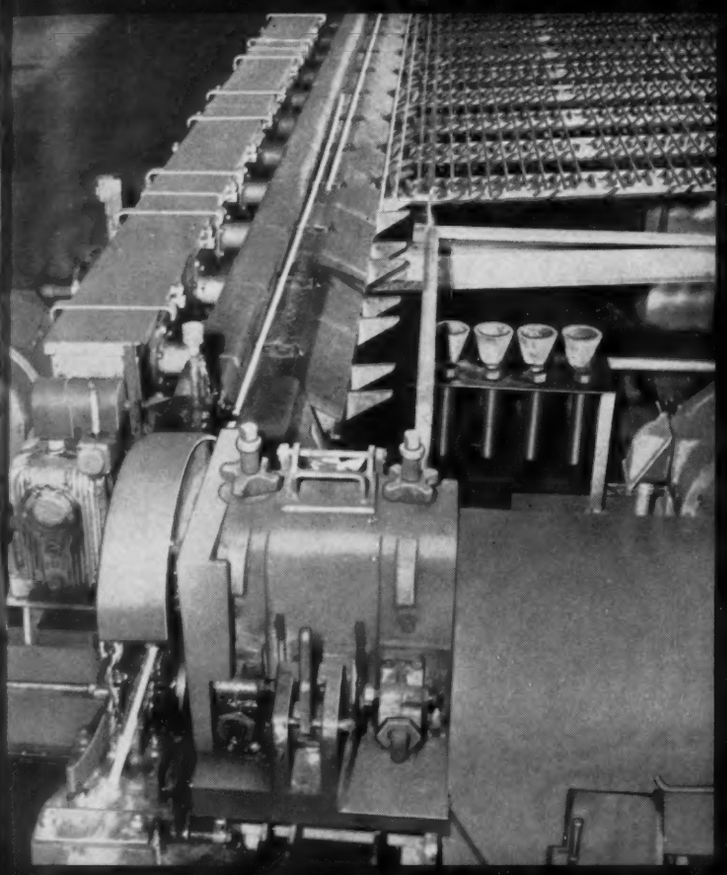

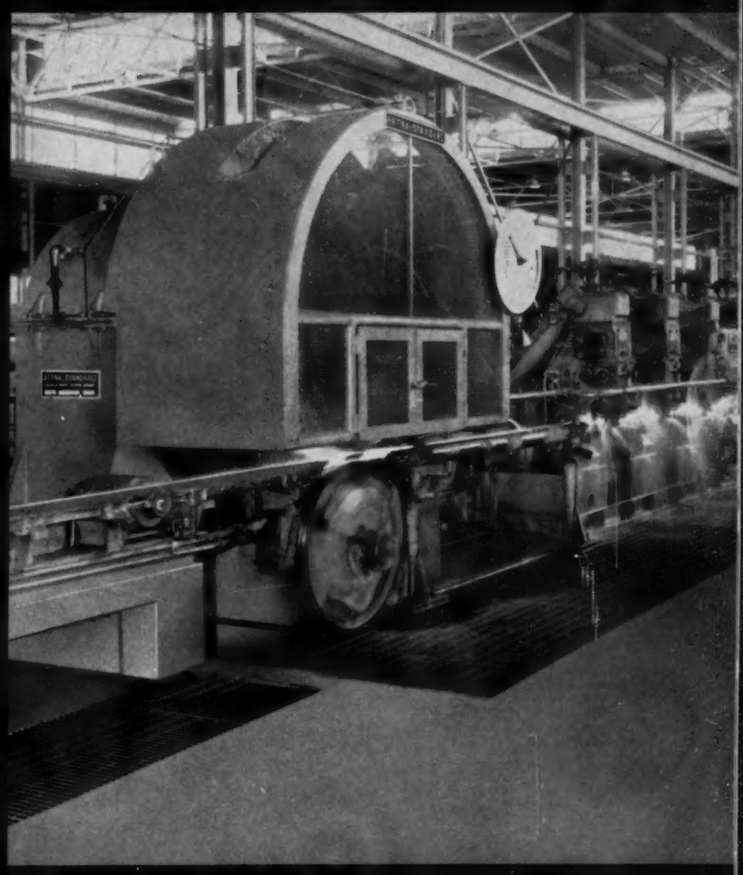

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- Transfers pipe to Cooling Beds at high speeds.
- Simple mechanical design.
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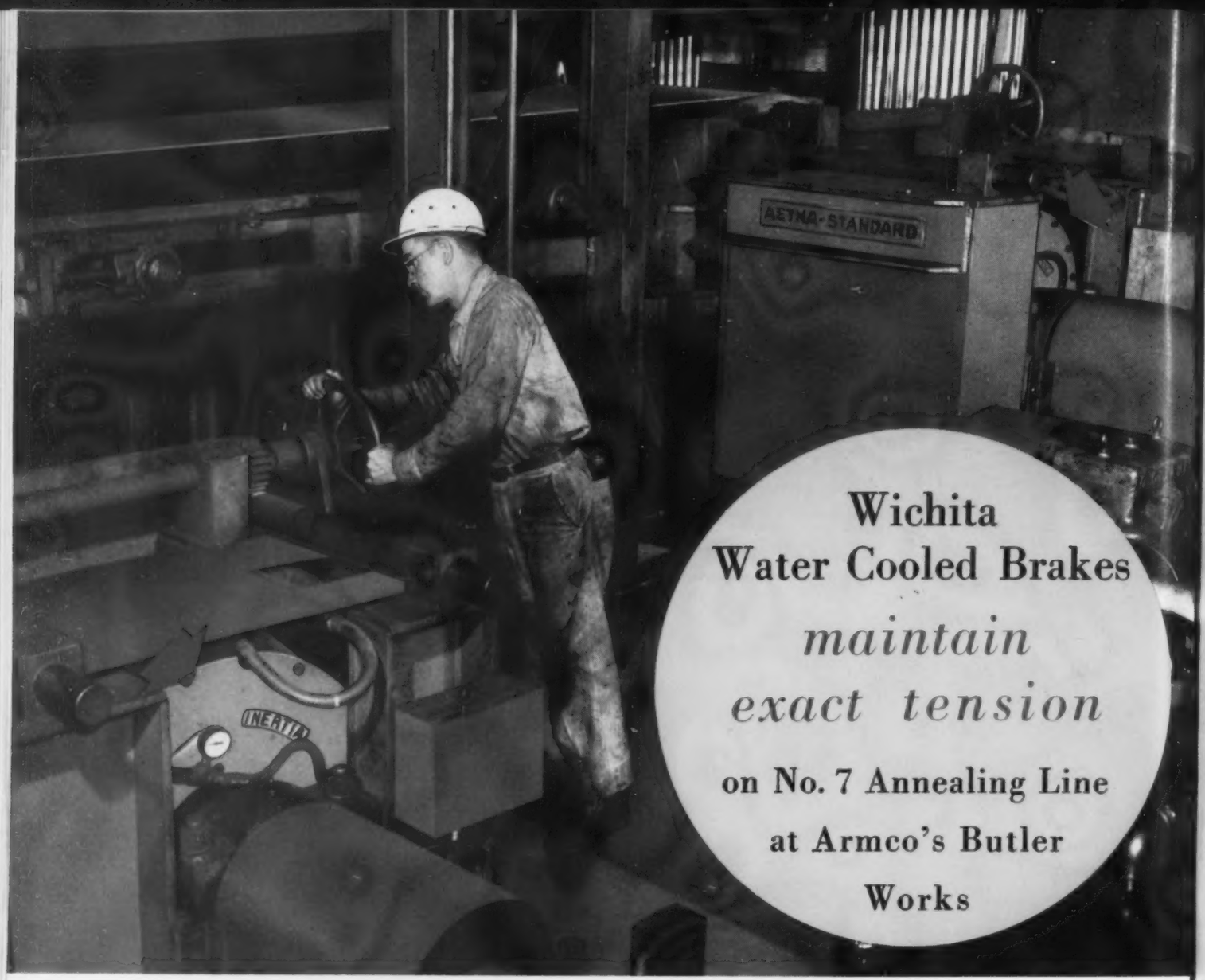
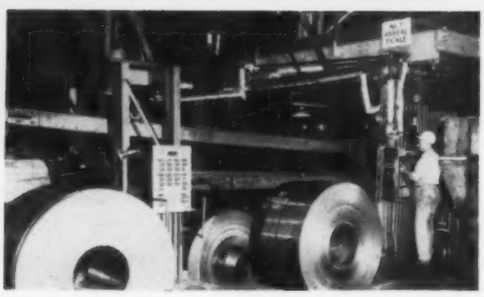


Wichita Water Cooled Brakes *maintain exact tension* on No. 7 Annealing Line at Armco's Butler Works



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Continuous service under exacting conditions of tension control are all in a day's work for the Wichita Water Cooled Brakes on this annealing line. Wichita Clutches and Brakes are used where the going is tough.

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Write for Wichita General Catalog

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Iron AND Steel ENGINEER

Volume XXXVIII · Number XII **DECEMBER, 1961**

71 Roll Wear in Finishing Trains of Hot Strip Mills
by Dr. George Sachs, James V. Latorre and M. K. Chakko

93 The Influence of Capital on Productivity
by William T. Hogan, S. J.

97 Elimination of a Coke Plant Relief Holder
by H. E. Taylor

104 Fundamentals of Heat Distribution and Refractory Wear in Electric Steel Furnaces
by W. E. Schwabe

113 The Next Step in Steel Plant Data Processing
by W. N. Spray

121 Oil Mist Lubrication on Anti-Friction Backup Roll Bearings
by C. W. Southerington

131 Electrochemistry in the Steel Industry
by E. E. Vonada

137 Electric Furnaces or Cupola-Basic Oxygen Converters?
by J. M. Bertram

140 Current AISE District Section Meeting Notices

141 Ceco's Ochiltree Works Modern Electric Furnace, Bar and Merchant Mill
by W. B. Jacobsen and Lawrence S. Barker, Jr.

150 The Power Distribution System of an Integrated Steel Plant
by Donald Stewart, Jr.

156 Development of USSR Iron and Steel Industry—II
by Ivan Denisenko and Roman Belan

161 Coke and By-Products in 1960
by G. M. Gaudio and I. E. Madsen

171 Recently Completed Basic Oxygen Shop to Furnish Steel for New J&L Hot Strip Mill

177 Alan Wood Dedicates New Plate Mill

181 Detection Equipment Combines Novel Magnetic Variations and Modular Construction

187 Pipe Measurement System Functions Automatically

261 AISE Yearly Index

DEPARTMENTS

11 Crops and Shorts
21 Patent Reviews
69 Steel Angles
193 Date-line Diary
203 Industry News
211 Publication Service
221 Personnel News
245 Equipment News
269 Index to Advertisers

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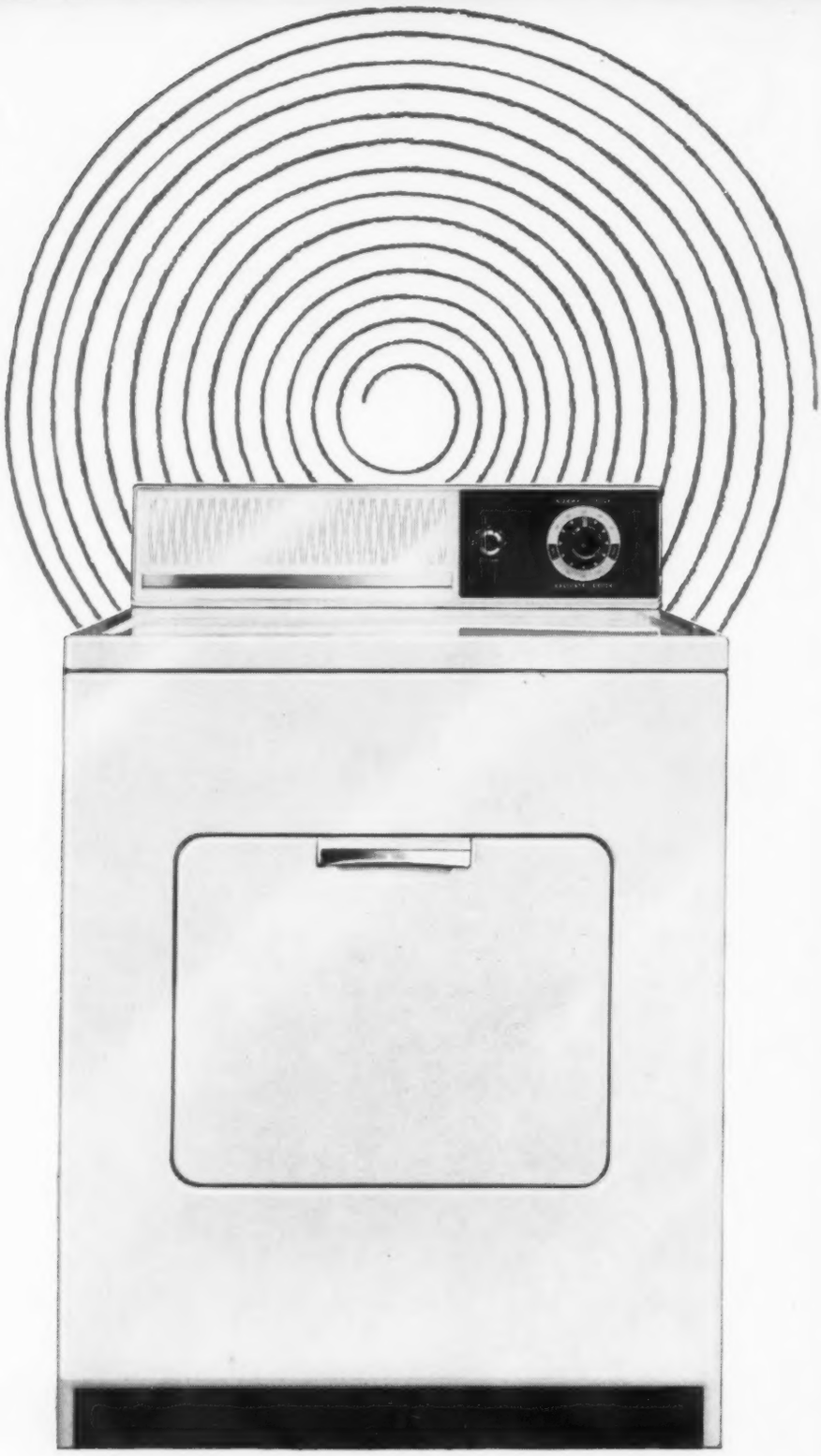

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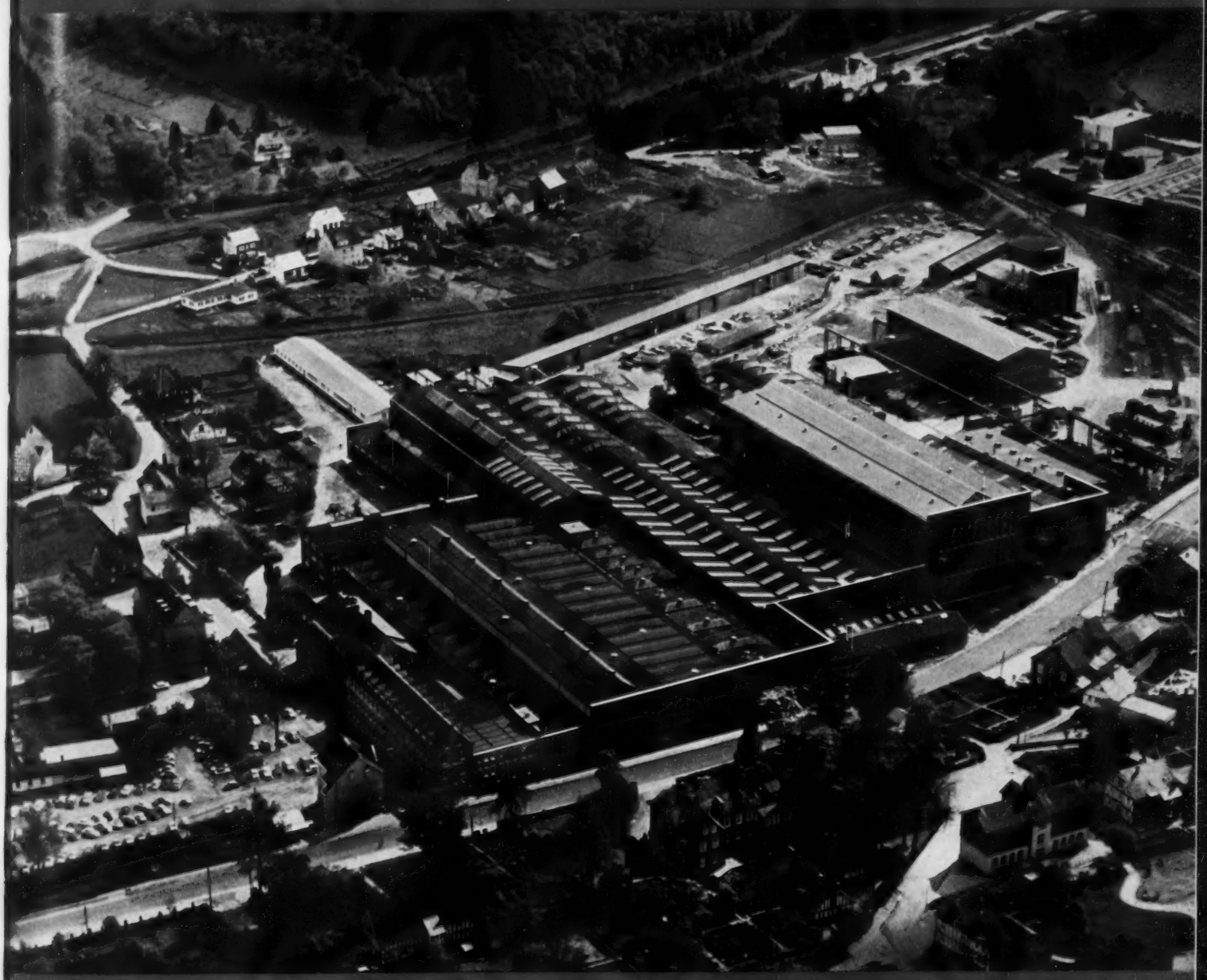

AW 96–61

Aerial view of our Dahlbruch Main Workshops with the recently erected buildings fitted with most modern equipment for machining and assembly of heaviest castings. At the right the new hall for machining heaviest mill housings up to 250 tons finished weight. Actually our workshop capacity is being increased again.

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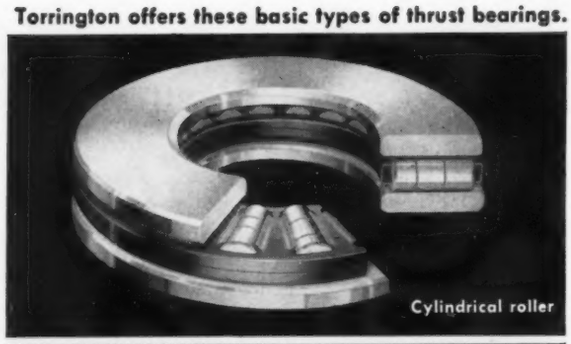
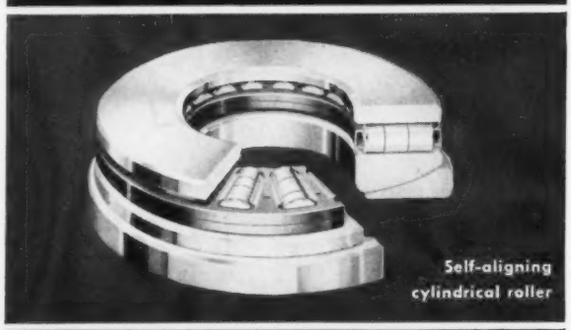
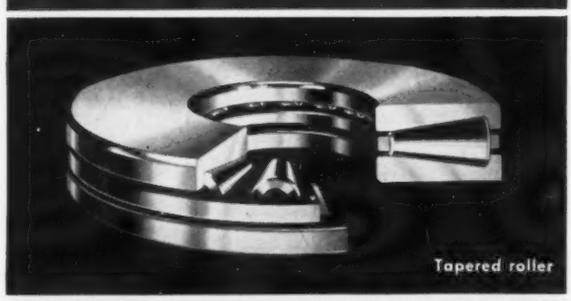
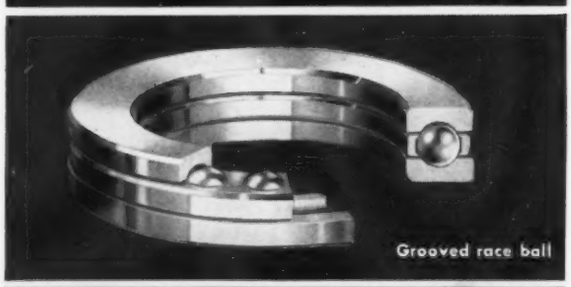
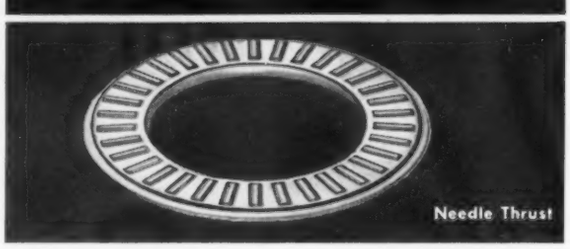

Cylindrical roller


Self-aligning cylindrical roller


Tapered roller


Grooved race ball

Angular contact ball


Needle Thrust

progress through precision

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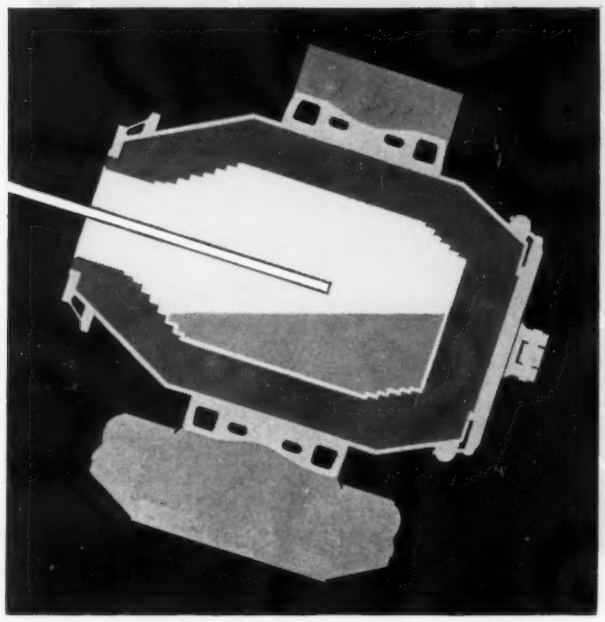

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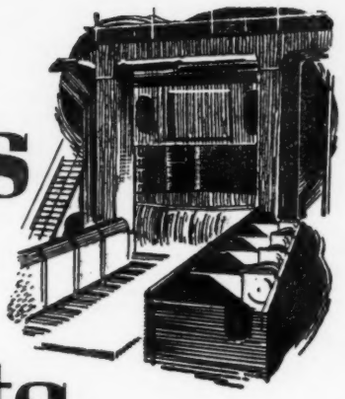


△ Stephen M. Jenks, executive vice president—engineering and research for United States Steel Corp., told a Chicago meeting of the Association of Iron and Steel Engineers that it is imperative that the steel industry learn to stay ahead of changes affecting its market. He said the industrialization goal of mass production for mass markets has been reached, but the industry must now find new materials with new properties.

△ There is probably no other country in the world where it takes more brains to make out an income tax return than it does to make the income.

△ Joseph L. Block, chairman of Inland Steel Co., told the Controllers Institute of America that inadequate profits are surely a serious deterrent to the modernization and growth of the steel industry. He believes that continuation of such a state of affairs could lead to the nationalization of the steel industry, and that, unless the return on capital invested can be drastically improved, the rate of progress in the steel industry will be too slow to serve properly the welfare of the country and all the people.

△ In the future, mention of the Gettysburg address will evoke the question: "Lincoln's or Eisenhower's?"

△ Reports from basic oxygen steelmaking installations continue to emphasize the advantages of the process. Jones & Laughlin Steel Corp. is producing at a rate of 240 tons per hour at their Cleveland works, while their Aliquippa works reports a lining life of 436 heats.

On the other hand, open hearths have been speeded up with the record of 100 tons per hour apparently at Steel Company of Canada. Various furnaces in the United States are running between 85 and 90 tons per hour.

And it is interesting to note the variance of opinions on the two processes that exist within any given company.

△ Expenditures by business in 1962 for new plants and equipment are expected to exceed those of the past five years.

△ Forrest H. Kirkpatrick, of Wheeling Steel Corp., believes many union leaders are concerned with two fears which stem from the changing composition of the nation's work force. The first comes from mechanization, with a decreasing number of so-called "blue collar" workers. The second springs from the gradual retirement of older, pre-union workers and the influx of younger post-union workers. Mr. Kirkpatrick says both fears generate a growing frustration among union leaders, and adds that it is well to remember that frustrated men are not always reasonable men.

△ A lot of people know how to say nothing but few know when.

△ The American Iron & Steel Institute reports that application of the various high-strength steels in railroad car construction has reduced the weight of cars by 16 to 30 per cent.

△ R. Heath Larry, administrative vice president—labor relations for United States Steel Corp., says that collective bargaining needs a climate for more effective use of the power of persuasion and less use of the persuasion of power. We must find more than just the means to achieve settlements—for they must become settlements with sense. He believes that, when management seeks to conduct relations with its employees with responsibility, integrity and recognition of their problems, it should be entitled to cooperation from unions in the improvement of attitudes, for surely the status of unions does not depend on forever fanning the flames of militancy.

△ Alarm clocks have been the subject of a lot of columnists recently. One definition: "a mechanism used to scare the daylights into you." Better yet: "a small mechanism used to wake up people who have no small children."

△ The use of aluminum in electrical applications is increasing. This field covers power transmission and distribution, electrical machinery, rigid conduit, communications equipment, capacitors, condensers, etc. The increase brought this field into third place as a consumer of aluminum, with 11.4 per cent of the total. The building products field continues to lead with 23.8 per cent, followed by the transportation field with 13.1 per cent. Containers and packaging, with 10.1 per cent, is fourth.

△ There is a sad commentary on the times in the recent news item concerning five union workers who were fined and suspended from their union for working at speeds above the standard provided in the contract, even though the extra production brought extra wages.

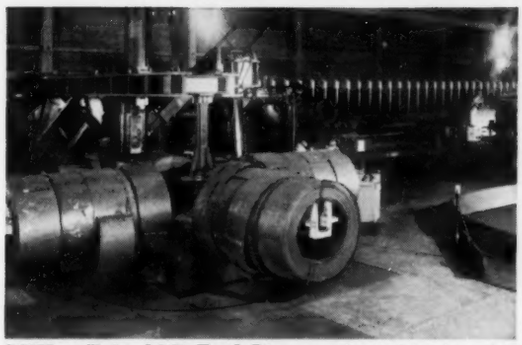
△ Dr. John C. Warner, president of Carnegie Institute of Technology, states there will be no more jobs for unskilled workers in 1970 than there are at present, but jobs for semi-skilled workers will have increased by 25 per cent and jobs for professional and skilled technical people by 60 per cent.

△ And to all our good readers: "A Merry Christmas and a Happy, Prosperous New Year."

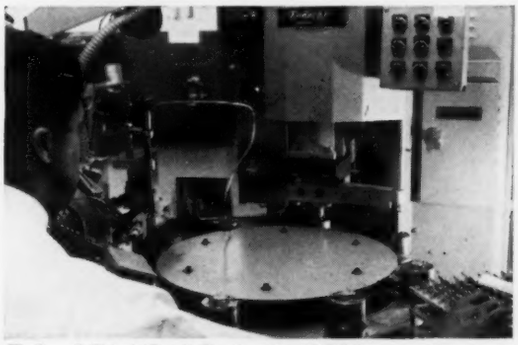
Warco
PRESS
400-2-60

◀ ***Warco Press Line*** composed of three 400-ton straight side, eccentric gear presses forms automobile wheel "spiders" at The Budd Company's Detroit plant. Here, William F. Longfield, manager of press engineering and sales for McKay's Federal-Warco Division, looks over a finished wheel with Edwin Seiberlich, works manager, and R. O. Greensbields, plant manager.

Photo by ARNOLD NEWMAN



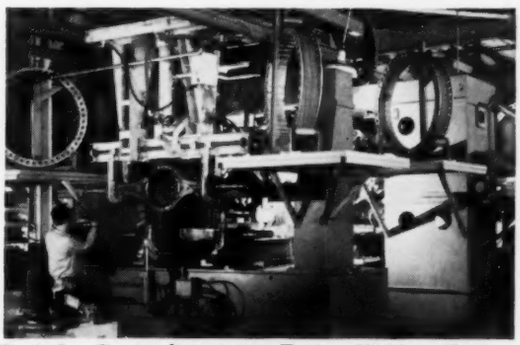
McKay Tube Mill Feed Line sends steel to the tube mill continuously at a rate of 1,800 fpm at U. S. Steel's National Tube plant at Lorain, Ohio.



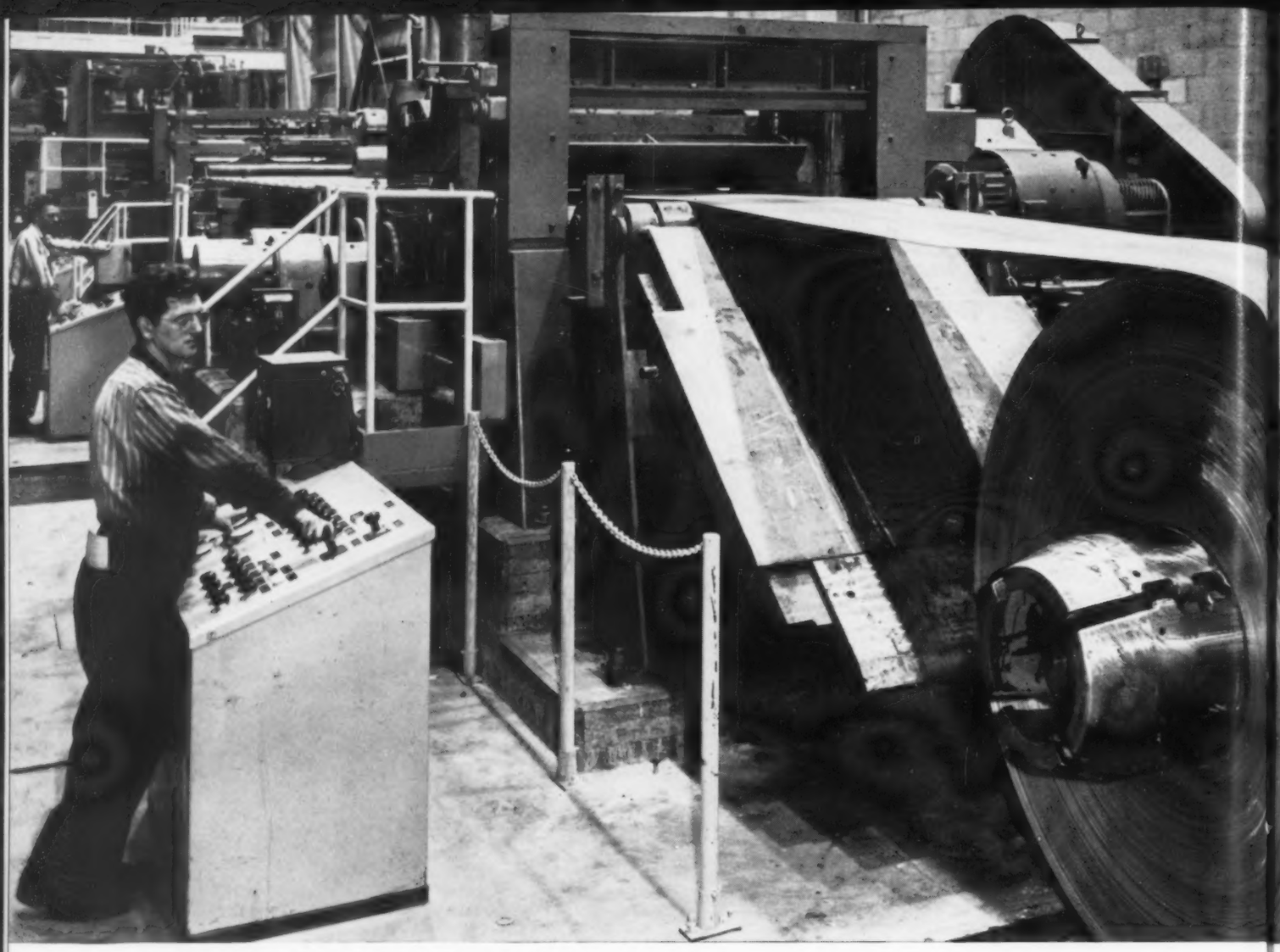
Federal Dial Feed Projection Welder, one of several used by the Bendix Corporation to weld transistor assemblies. It will weld 2,000 assemblies per hour with exacting precision.

Uncoiling, flexing, processing, slitting, shearing, feeding, forming, stamping, and welding . . . keeping ***metal in motion*** in the most economical manner possible, from coil to finished product, ***is the business of McKay Machine.***

McKay Machine, its divisions and subsidiaries produce the widest range of metal preparation, processing, forming and welding equipment available anywhere. Because of this they can design and build complete, integrated production lines of perfectly mated machinery. This makes it possible to achieve compactness and bring about efficiencies not otherwise practical. It also means the manufacturer is concerned with only a single source of responsibility and supply. That's why more and more cost-conscious metalworking firms are making it a point to know *The McKay Machine Company, Youngstown 1, Ohio.*



Berkeley-Davis Automatic Fusion Welding Lines, such as this one of two recently installed at American Metal Products Company in Detroit for the automatic production of over 200 sizes of motor vehicle axle housings, lead the industry in precision operation, production efficiency, and flexibility.



Feeding in strip at the entry reel of a galvanizing line in Hamilton, Ontario.

SINGLE RESPONSIBILITY FOR DRIVE SYSTEM DESIGN PAYS OFF FOR CANADIAN MILL

The motors, controls, regulators and sensing devices which drive this continuous galvanizing line were integrated to produce a precise performance by one totally responsible source . . . Reliance Systems Engineering.

The drive system was designed to utilize sectional generators and control, thus achieving more flexibility to handle a broader range of products. Any or all units of the line consequently can be changed to meet new production demands. Positive speed sychronization between sections is achieved with Reliance transistorized VSRR magnetic amplifier regulators.

Close control of the line is demonstrated by application of modern sensing devices. When light gauge strip is coiled, for example, a Reliance "Tensitron", senses, establishes and maintains tension at pre-set levels.

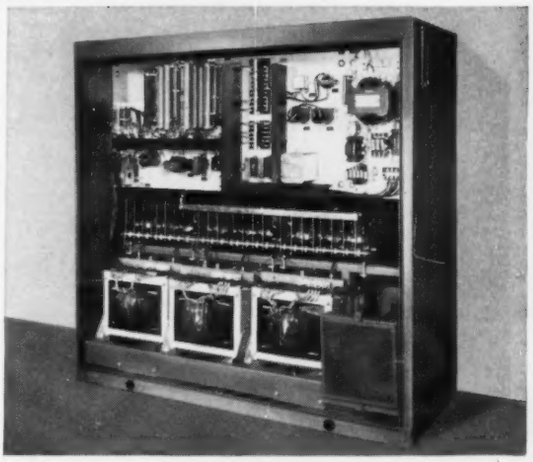
Precise tension and tracking of the strip was quickly created and preserved throughout all 32 sections of the line . . . and uniform, high quality strip was produced. Reliance willingly accepted *total responsibility* for the planning and engineering of this processing line drive at the request of the mill . . . with logical and practical results.

Reliance is ready and able to produce similar results for you. Your Reliance Systems Engineer can tell you even more about the advantages which can accrue to you through Reliance's Total Responsibility and Total Service. Call him —through your nearest Reliance office—or if you prefer, write us direct.

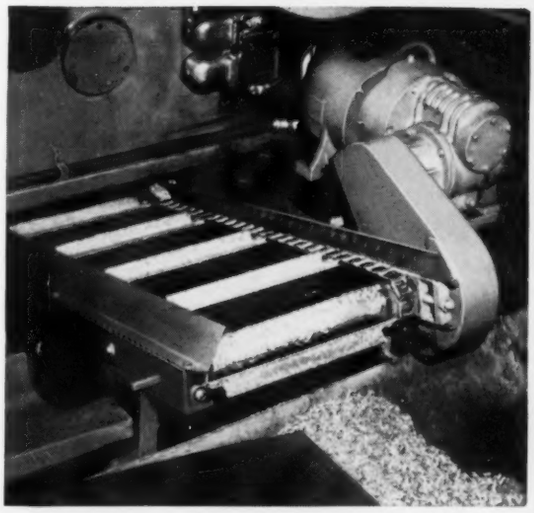
A-1687

RELIANCE...
builders of the tools of automation

NEW DUTY MASTER D-5000 design brings you new standards in coolness, quietness . . . and more horsepower in less space. Frame dimensions that held 150 hp. now contain 300 hp. There is better heat dissipation from the frame itself. Air flows easily through the entire grilled end areas—exhausts through long, protected slots at the sides and bottom. New fingerless ducted rotor design means better cooling than any other previous motor. You get all famous Duty Master features in this new D-5000 . . . special lubrication design, drip or splash-proof and complete open motor protection. Bulletin B-2515.

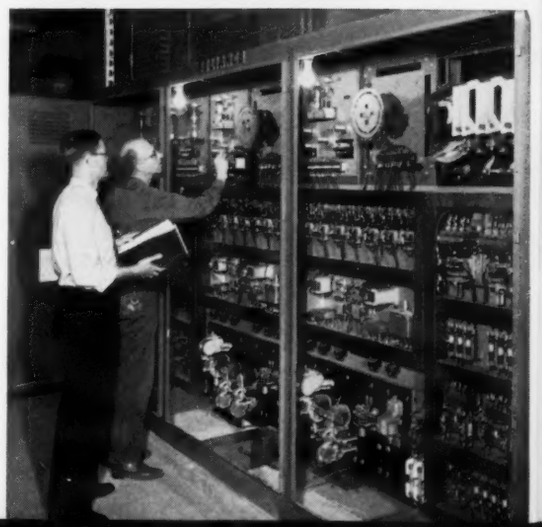


RELIANCE V★S STATATRON is a static powered drive for wide range variable speed from in-plant a-c. circuits, available from 1 to 200 hp. Instead of a motor-generator set, the Statatron uses silicon diodes and saturable reactors to rectify the current from a-c. to d-c. These work in combination with a transistorized power exciter to supply variable voltage. Statatron is compact—35% smaller than conventional units. Consists of only three components: Super 'T' d-c. motor, operator's station and control cabinet. Statatron is quiet—vibrationless and low in maintenance cost. Bulletin D-2508.



THIS MASTER GEARMOTOR drives a chip conveyor on automatic screw machine. The combination parallel and right angle reduction produces efficient low output speed at high torque—ideally suited to this operation. Features important here are its compactness and one piece construction, saving space and maintenance. This Master Gearmotor is impervious to liquids . . . splashing of coolant and any other outside contamination. Where the situation calls for gearmotors, this full line can cut your engineering and assembly costs . . . give you dependable performance. Bulletin E-2409.

TOTAL SERVICE is an integral part of every Reliance product, from engineering and start-up assistance to maintenance and renewal parts. The photo shown here is typical of a Reliance Service Engineer's on-the-job availability—for maintenance and consultation on knotty problems. Every Reliance Sales Engineering Office and Distribution Center—nationwide—gives you the attention and experience necessary to assure the top performance you expect from the Reliance equipment you buy.



RELIANCE ELECTRIC AND ENGINEERING CO.

DEPT. 11-12 CLEVELAND 17, OHIO • Canadian Division: Toronto, Ont.

WAGNER® HYDRAULIC CRANE BRAKES *help speed cargo handling*

There are four Wagner® Hydraulic Crane Bridge Brakes aboard Inland Steel Company's S. S. EDWARD L. RYERSON. Specially engineered for high holding torque, they are used for parking and holding the gantry crane that handles the ship's hatch covers. These four Type HM 6″ x 3″ brakes are all operated from one station . . . make it possible to open hatches with the speed and safety that results in faster handling of cargo.

Wagner Hydraulic Crane Bridge Brakes can increase the productivity of your operation, too. They stop cranes accurately and smoothly . . . so important in operations where frequent starts and stops are necessary; where close spotting is required; where heavy equipment is involved.

These proven industrial crane bridge brakes are increasing production rates in other applications:

- **Emergency stopping of machinery**
- **Holding and controlled braking on fluid power drives**
- **Manual tension control or drag braking**
- **Remote and manned-trolley controlled service braking and holding**
- **Special power braking**

Let your nearby Wagner Sales Engineer help you select the *right* Wagner Industrial Braking System to meet your requirements. Write for Wagner Bulletin IU-226.

Wagner Electric Corporation

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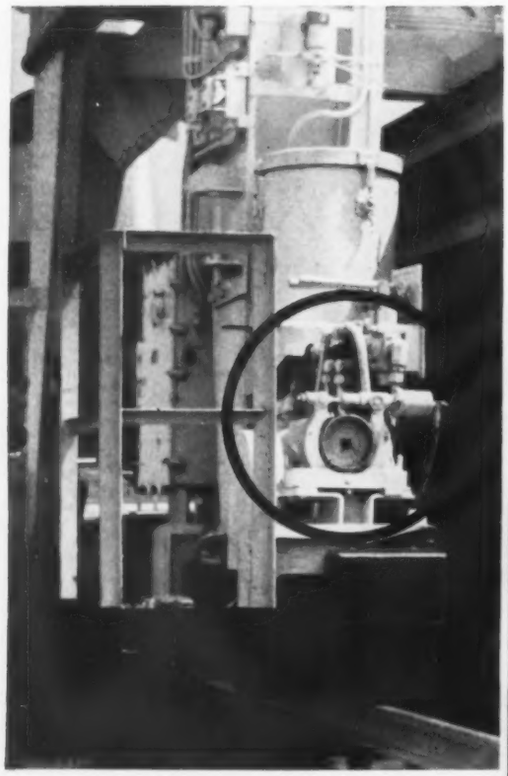
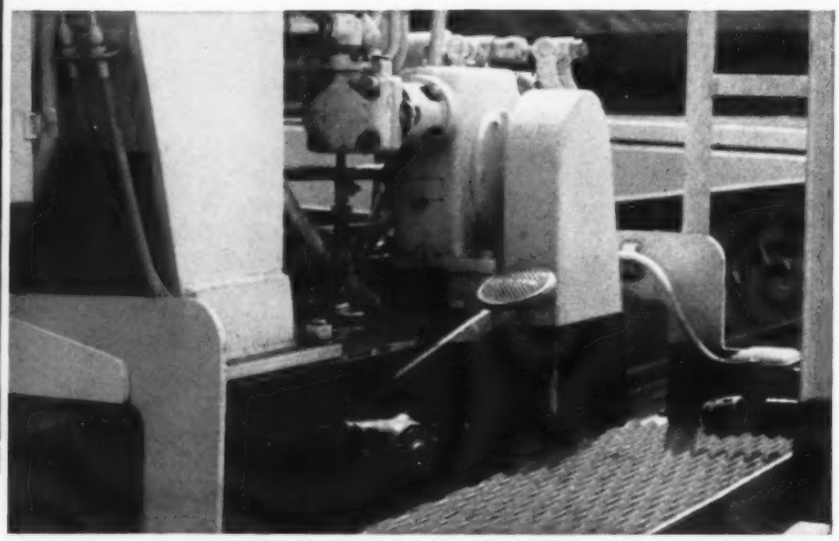
W161-2



One of the four Wagner type HM hydraulically operated service brakes, with spring-applied parking means, that help speed the opening and closing of the hatches to minimize "hold-up" of the ore boat at the dock.



All four Wagner brakes on the S. S. EDWARD L. RYERSON'S gantry crane are operated from this single station.

Ingot Mold Cars . . .

built to last by a company that uses them!

5 unique structural features make them better

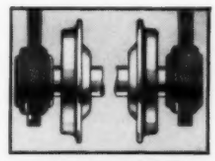
Ingot Mold Cars take more punishment than perhaps any other cars in a modern steel plant. In the 40 years we have been making these cars for our own use, United States Steel has developed a number of features in structural design that assure longer life, less maintenance and dependable service.

Shown here is a typical 8-wheel, 200-ton capacity Ingot Mold Car. The advantages illustrated at the right—plus the rugged durability of all-welded rolled-steel construction—make any size USS Ingot Mold Car a profitable investment.

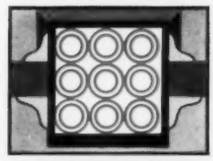
Our representative will be pleased to call at your convenience to discuss your requirements for this or any other type of industrial car. For more information, write to United States Steel, 525 William Penn Place, Pittsburg 30, Pennsylvania. USS is a registered trademark.

United States Steel Corporation • Columbia-Geneva Steel Division • Tennessee Coal and Iron Division • United States Steel Export Company

USS United States Steel

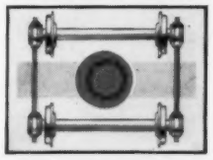


Anti-friction outboard bearings: High-capacity anti-friction bearings are located *outside* each of the car's eight wheels to minimize sidesway and to provide long, smooth-running performance.



Seventy-two coil springs: Nine coil springs between each two wheels on both sides of the car—plus nine overload coils *inside* these—provide a total of 72 separate springs for a shock-absorbed *level* ride, so important in hauling molten metal.

High engineering safety factor: Designed for a 200-ton normal capacity load—including ingots, molds and stools—each car has a substantial built-in safety factor to withstand maximum ingot-stripping thrusts.



Oversize center plates: "Beefed-up" center plates between the trucks and car body are 18 inches in diameter—compared with the conventional 12 inches—to reduce the load per square inch on their surfaces.

Hot-metal shields: Curved end plates, long side skirts, and special drip shields protect the couplers, bearings and springs from runover molten metal and troublesome solidified drippings.

SWINDELL

ENGINEERING Swindell-Dressler engineering covers the range of steelmaking requirements from feasibility studies to complete plants and owners' key. Integrated steel mills, basic oxygen steel plants, electric steel melt shops, gas cleaning systems, departmental expansion or remodernization are among the many areas served by this long-experienced metals engineering organization.

ELECTRIC ARC MELTING FURNACES

ADVANCED DESIGN FEATURES—

- **3 Point Roof Suspension**
- **Flush Door Mechanism**
- **Remote Roof Cylinder Mounting**
- **Mechanical Tilting**
- **Expendable Shell Panel Construction**

Swindell-Dressler—manufacturer of electric arc melting furnaces for almost 50 years—has pioneered many of the significant advances in this field. Today's Swindell electric arc units embody every modern feature for increased production rates, lower production costs, and improved quality of product. Swindell Electric Arc Furnaces range in capacity from a few hundred pounds capacity to 100 tons and more.

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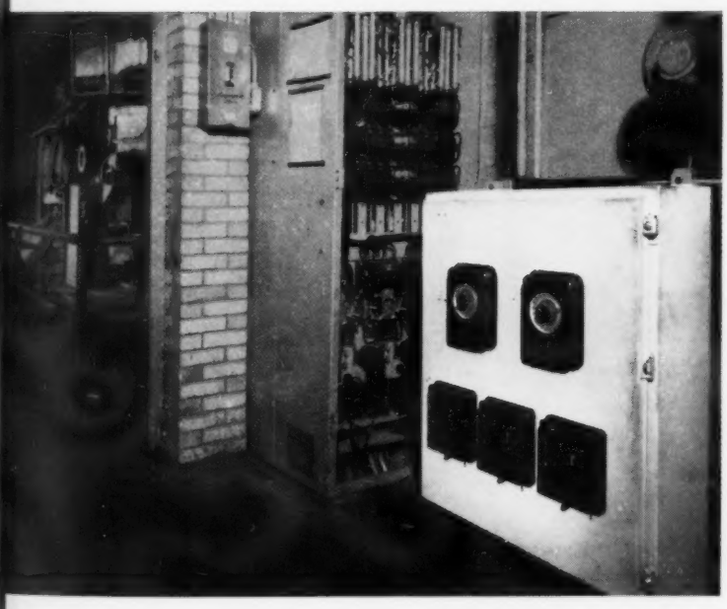
AUTOMELT®

Automatic Power Control for Electrode Regulators



- **Lowers Production Costs**
- **Improves Product Quality**
- **Reduces Electrical Consumption**
- **Minimizes Electrode Breakage**
- **Lowers Maintenance**

Swindell-Dressler's new Automelt Automatic Power Control, thoroughly proved in the field, provides the above advantages through efficient and dependable control of power application during melt-down or any phase of the heat cycle. Automelt minimizes occurrence of dead short circuits resulting from scrap shifting or major cave-ins by automatic electrode withdrawal, reclosing the circuit, lowering electrodes and restoring power—all without attention by furnace operators. Automatic high-speed electrode raising in preparation for roof swinging is another valuable Automelt function. Automelt can be adapted to most of today's electrode regulators, and can also be employed in connection with electric arc hot-topping units. Write for details!

SWINDELL-DRESSLER

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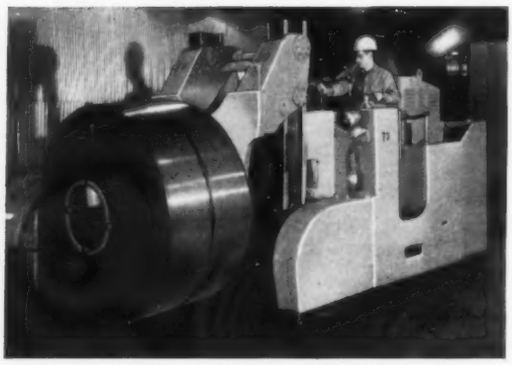
ELPAR at Armco Steel–Butler Works



Elpar trucks are steel mill veterans. When loads are heavy, conditions are rugged, hours are long, Elpar delivers top-rate performance . . . always.

Write for the Titan Bulletin for trucks to 20,000-pound capacity . . . or the Hercules Bulletin for larger models.

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ELECTRIC TRUCKS

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TWICE THE LIFE...ONE THIRD THE OPERATING COST

patent reviews

by MELVIN NORD, Patent Attorney, Detroit, Mich.

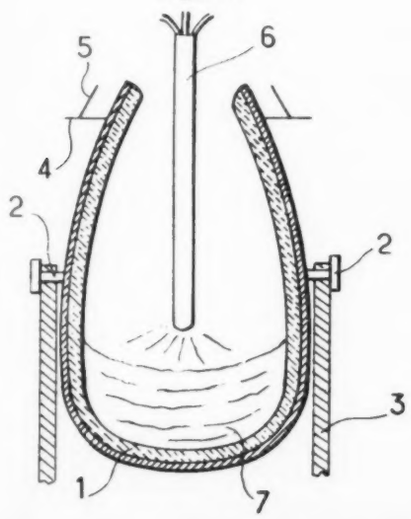
Copies of patents may be obtained from the Commissioner of Patents, Washington 25, D. C. at 25 cents . . . patents reviewed cover period July 25, 1961 to August 22, 1961

METHOD FOR TREATING STEEL IN VACUO

△ U. S. 2,993,780, issued July 25, 1961 to Marc Allard and assigned to Institut de Recherches de la Siderurgie, provides a vacuum method of production of steel in a very high state of purity. The main object of the invention consists in producing conditions allowing each elementary volume of metal to be subjected to a reduced ferrostatic pressure, by resorting to stirring movements produced by the gases. This allows the use of a reduced vacuum.

The metallurgical container used as illustrated in Figure 1 is given an elongated shape. It is provided with trunnions 2 which allow setting it on a support 3. A lance 6 is adapted to provide for the treatment of a metal bath 7 inside the container.

Figure 1



The gas withdrawing system is illustrated in Figure 2. The flange 4 cooperates with a packing 8 made of rubber or plastic and carried by a cover 9 provided with an inspection gate 10 which allows checking with withdrawal of the gas.

The container 1 rests on the electromagnetic skimming device 15 carried by the carriage 16. This electromagnetic skimming device may pivot round a spindle 17, as shown in Figure 3, so as to allow the skimming to be executed.

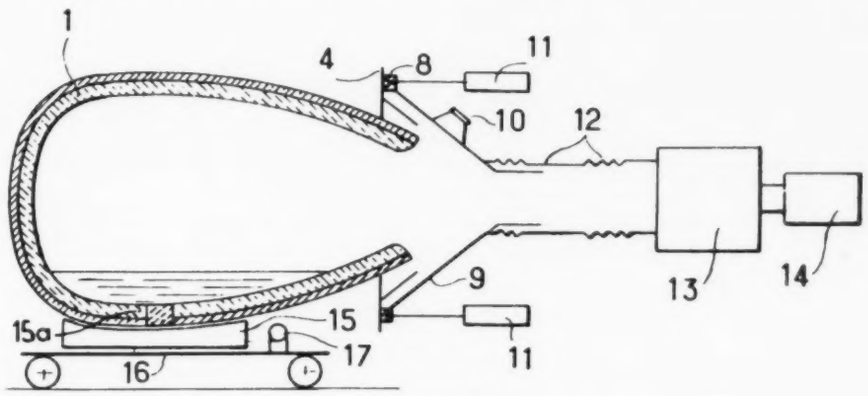
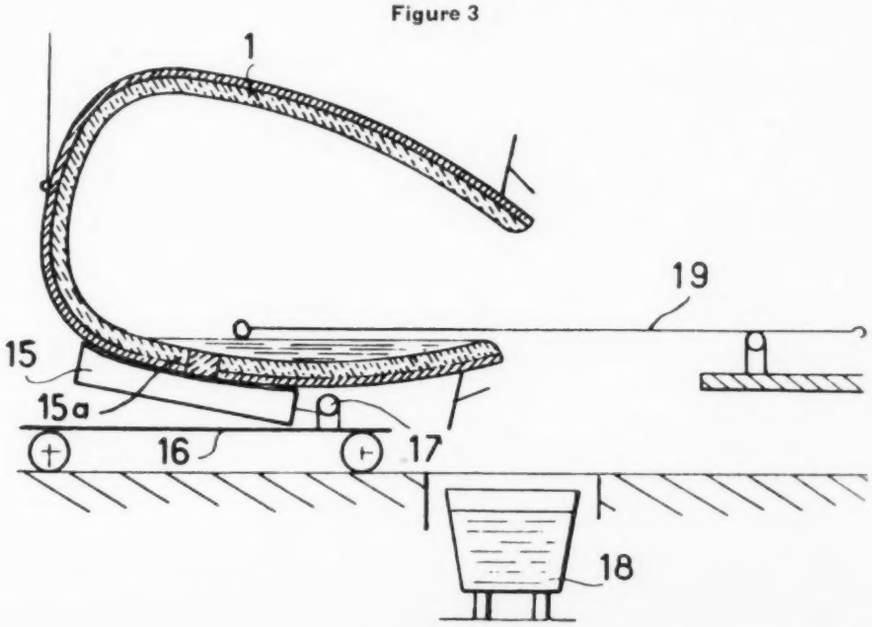


Figure 2

Figure 3



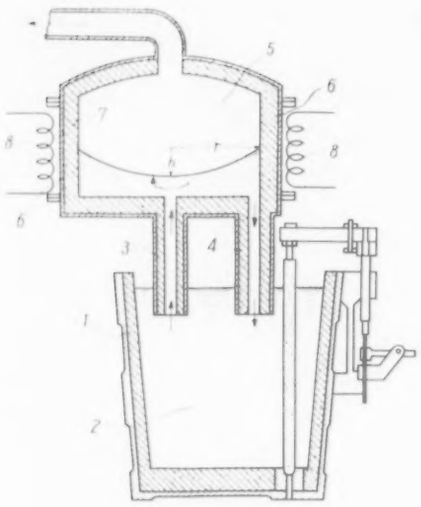


Figure 4

DEGASIFYING MOLTEN STEEL BY CIRCULATION

△ U. S. 2,994,602, issued Aug. 1, 1961 to Kamematsu Matsuda and assigned to Yawata Iron & Steel Co., Ltd., relates to a method of vacuum degasifying molten steel, in which the molten metal is continuously introduced into a vacuum chamber and subjected to circulation therein.

As shown in Figure 4, a vacuum chamber 5 having two pipes 3 and 4 lined with refractory, the ends of which dip into the molten steel 2 contained in the ladle 1, is exhausted by an evacuating pump (not shown) to vacuum. Then the molten metal is drawn up into the vacuum chamber. The vacuum chamber is constructed of a cylindrical shell 6 made of a nonmagnetic metal lined with a suitable refractory 7 and surrounded by the coil 8 of a rotary magnetic field. When this coil 8 is supplied with electric current to energize the rotary magnetic field, the molten steel moves in a rotary motion, with the result that the level of the molten steel in the vacuum chamber turns into a parabolic surface, as shown.

The molten steel in the ladle rises up through the pipe 3 continuously and falls down through the pipe 4 after degasification in the vacuum chamber.

AUTOMATIC SELF-CENTERING PULLEYS FOR BELT CONVEYORS

△ U. S. 2,995,945, issued Aug. 15, 1961 to Edwin T. Lorig and assigned to United States Steel Corp., relates to automatic self-centering pulleys or rolls for belt conveyors and more particularly to pulleys which can be used with reversing conveyors.

The object of the invention is to provide flat idler pulleys for belt conveyors which will center the belt regardless of direction of travel, without damaging the edge of the belt.

The apparatus is shown in Figures 5 and 6. Assuming that the belt is moving from right to left as seen in Figure 5, and that the belt hangs in shallow loops between each pair of troughing idlers, each

OTHER PATENTS OF INTEREST TO THE IRON AND STEEL ENGINEER

Patent No.	Date	Subject	Inventor or assignee
2,993,269	7/25/61	Production of titanium-clad iron	General Electric Co.
2,993,393	7/25/61	Edge roll control for wheel rolling mills	Edgar H. Kendall
2,993,724	7/25/61	Drop-bottom charging bucket for charging metallurgical furnaces	Deutsche Edelstahlwerke AG
2,993,757	7/25/61	Recovery of acid values from mixed acid waste	Crucible Steel Co. of America
2,993,759	7/25/61	Treatment of iron ore	The M. W. Kellogg Co.
2,993,779	7/25/61	Reduction of metal oxides	Elektrokemisk A/S
2,993,781	7/25/61	Production of steel in a regenerative furnace	United States Steel Corp.
2,993,845	7/25/61	Metal-plug type coke-oven door	United States Steel Corp.
2,994,600	8/ 1/61	Iron powder for making sintered iron articles	Friedrich Hansen
2,994,601	8/ 1/61	Recovery of nickel from nickel and oxide iron ores	Albert E. Greene
2,995,354	8/ 8/61	Operation of cupola furnaces	Gesellschaft fuer Huettenwerksanlagen m.b.H.
2,995,441	8/ 8/61	Production of pearlitic malleable cast iron	Walter Overhoff
2,995,455	8/ 8/61	Recovery of nickel and iron from laterite ores	Tohoku Denki Seitsetu Kabushiki Kaisha
2,995,816	8/15/61	Method of casting clad steel	Lukens Steel Co.
2,996,372	8/15/61	Production of lump ore	Blocked Iron Corp.
2,996,376	8/15/61	Low alloy steel having high hardness at elevated temperatures	Crucible Steel Co. of America
2,996,772	8/22/61	Vacuum casting apparatus	United States Steel Corp.
2,996,937	8/22/61	Rolling of metal stock	Hans Cramer
2,997,219	8/22/61	Hold-down roll for strip processing line	United States Steel Corp.
2,997,288	8/22/61	Cupola furnace installation	Hans L. Schwechheimer, et al.
2,997,372	8/22/61	Determination of the phosphorus content of a steel specimen	United States Steel Corp.

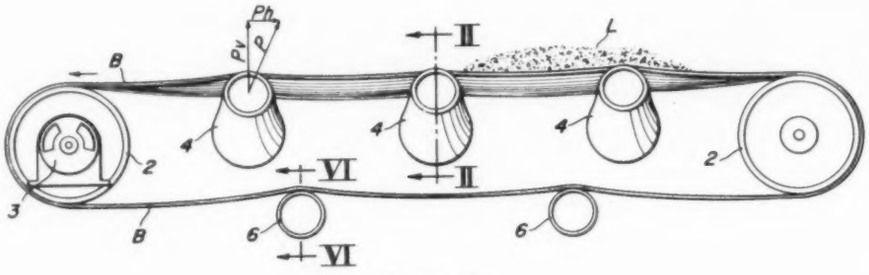
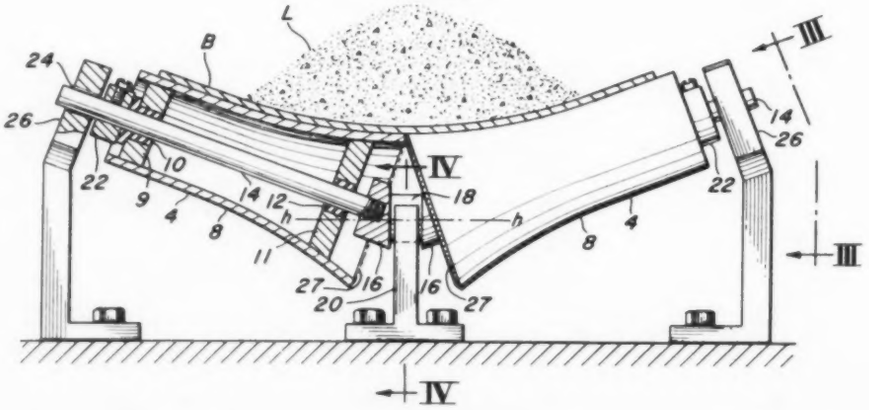
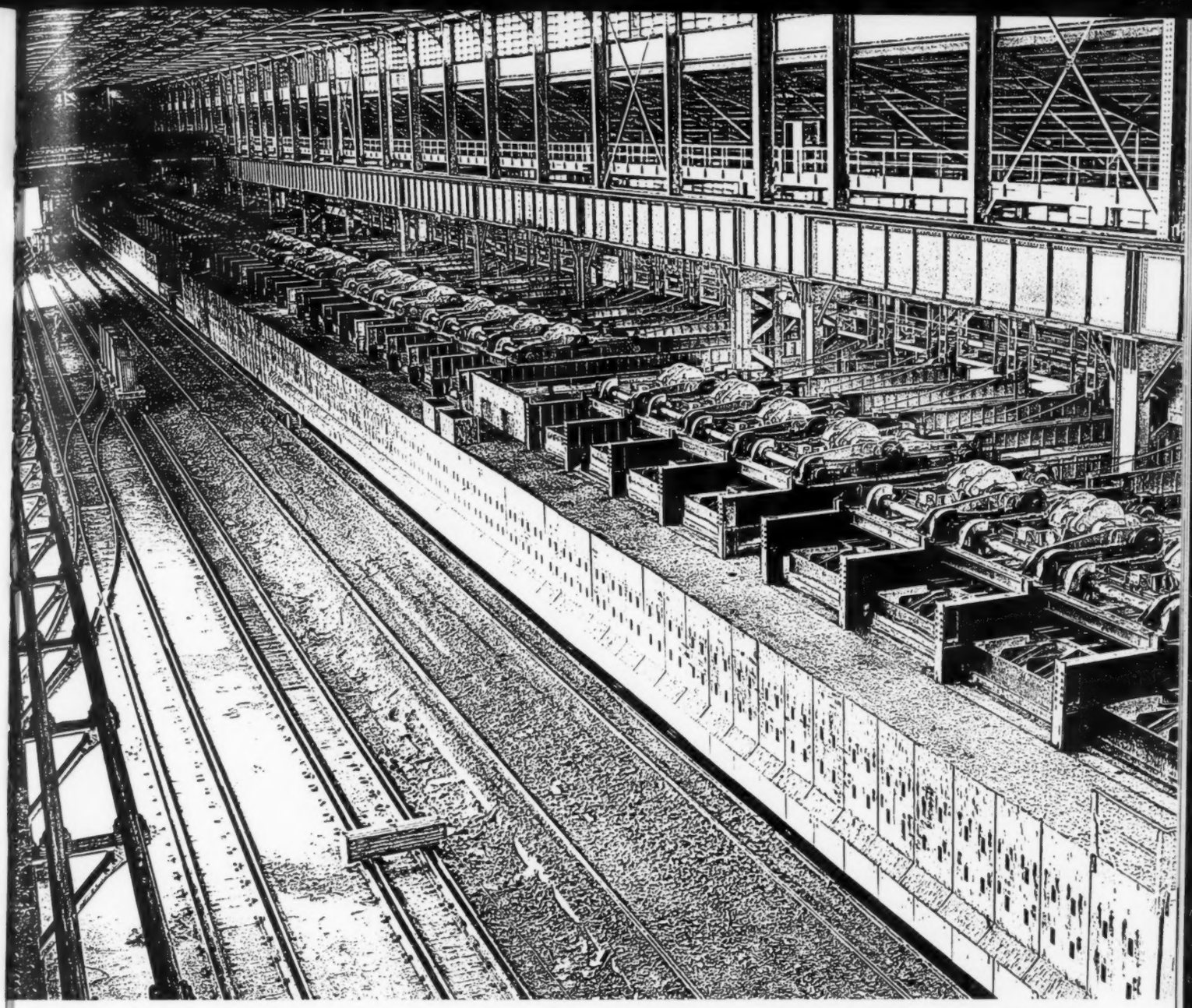


Figure 5

Figure 6





Courtesy of Gary Works, U.S. Steel Corporation

Gets them out the back door (750 tons/hr) This is the largest installation of soaking pits (48) ever built at one time. Engineered by Surface, it will heat an average of 750 tons per hour. At peak capacity, it loads the ingot buggies at a rate of 1200 tons per hour. A dual recuperator system applies the maximum amount of heat where it belongs—inside the pit. Address inquiries to 2404 Dorr St., Toledo 1, Ohio.

SURFACE

SURFACE COMBUSTION, Toledo 1, Ohio/ a division of Midland-Ross Corporation MR

HAGAN POWRMAG CENTRALIZED

integrates operation of open hearth–waste heat boiler–precipitator complex at J&L's Pittsburgh Works

Hagan PowrMag (Magnetic Amplifier) control systems plus a Hagan AIM (Alarm Indicating Monitor) are helping to lower operating costs of a new open hearth dust control installation at Jones & Laughlin's Pittsburgh Works.

The system integrates the control of eleven waste heat boilers with the requirements of eleven open hearth furnaces and eight electronic precipitators. The graphic panel and the Hagan AIM are housed in a forty-foot control room located in the center of the quarter-mile long shop. This centralized control makes it possible for one man to supervise the operation of the entire system. The Hagan AIM provides both audible and visible alarms if any one of 220 critical flows, temperatures or levels go out-of-limits.

For more information on this cost-saving installation, call your Hagan engineer, or write for the folder "Hagan and Steel—No. 2."

Hagan Controls at J&L's Pittsburgh Works

Waste heat boiler draft control—The hot gases from the open hearth checkers can be diverted either directly to the stack or through the waste heat boilers, and then on to the precipitators.

Metering—Ring Balance meters are used to measure steam flow to the power house, steam from each waste heat boiler, and a portable meter is used for checking steam for auxiliaries.

Feedwater control system—A special Hagan two-element system is installed to maintain accurate level control under the wide and rapid load changes experienced in the open hearth system.

Feedpump pressure and recirculation control—There are three feed pumps for the entire plant, any one of which can carry full load . . . all under Hagan control.

Precipitator balance control—A large plenum collects the gases from the eleven waste heat boilers and discharges into the eight precipitators. Hagan control balances the flow equally between the precipitators.

Alarm indicating monitor—Designed to monitor any input that can be represented by a DC voltage as low as 10 millivolts full scale, the Hagan AIM at the Pittsburgh Works monitors critical temperatures, pressures and levels.

Display lights on the AIM's control panel indicate to operators that out-of-limits conditions are occurring and the point's name and number. A horn is also sounded; the horn can be silenced, but the light stays on until the condition is rectified.

CONTROL

HAGAN
CHEMICALS & CONTROLS, INC.
HAGAN CENTER, PITTSBURGH 30, PA.

HAGAN DIVISIONS: CALGON CO.
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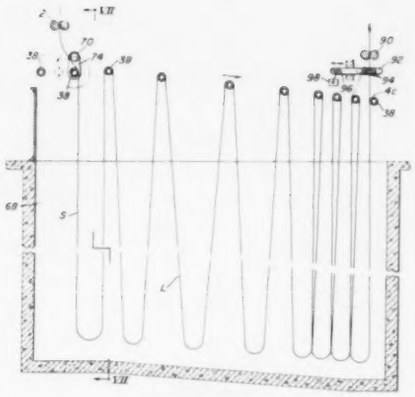


Figure 7

particle of the load L will change its direction of travel as it follows the loop. The force required to change the direction of the belt B is provided by the pressure of the pulley against the belt, this pressure being indicated by the arrow P in Figure 5. Pressure P has a horizontal component Ph which causes the shafts 14 to rotate in the direction of belt travel to the one end of slots 24. The movement of the ends of the shaft 14 causes a toe-in effect on the pulley shells 8 which produces a centering effect on the loaded belt. As the direction of belt travel is reversed, the direction of force P is also reversed, and the shafts 14 will rotate about the h-h axis in the opposite direction and to the opposite end of the slots 24.

STRIP ACCUMULATOR

△ U. S. 2,996,230, issued Aug. 15, 1961 to Alfred Teplitz and assigned to United States Steel Corp., provides an accumulator for storing heavy steel strip on either or both ends of a strip processing line, which can handle the strip regardless of its gage or flexibility.

Portions of the apparatus are shown in Figures 7 and 8.

A 3-STAGE FLUIDIZED-REDUCTION PROCESS

△ U. S. 2,996,373, issued Aug. 15, 1961 to Jagdish C. Agarwal and assigned to United States Steel Corp., provides a 3-stage continuous direct reduction process for iron oxide in fluidized beds.

An object of the invention is to provide an improved 3-step fluidized-bed direct-reduction process for iron oxide wherein the percentage

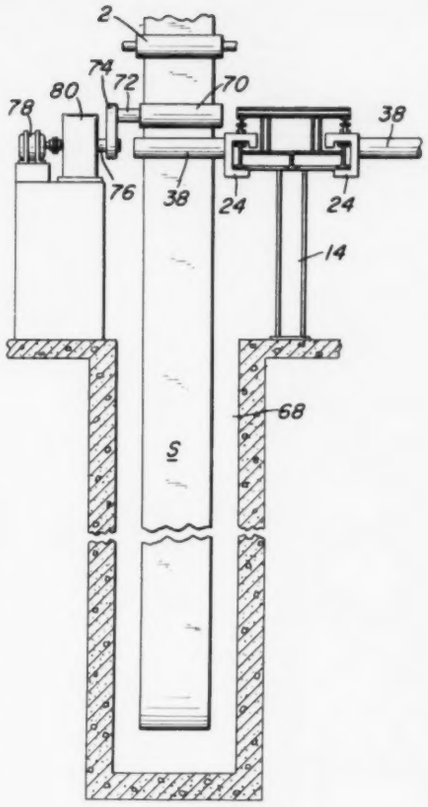


Figure 8

by which ferrous oxide is reduced in the second and third steps is apportioned in a novel and critical way that produces successful operation.

As shown in Figure 9, the process includes three reduction steps in series, each conducted in a respective fluidized bed. In the first step, higher oxide (indicated as Fe_2O_3) is reduced to a product predominantly FeO. In the second step, this product is partially reduced to metallic iron. In the third step, the product from the second step is further reduced to a product predominantly metallic iron. The gas flows counter to the iron-oxide fines, off-gas from the third step being used as reductant in the second, and off-gas from the second being used as reductant in the first. The iron-oxide fines are preheated to about 1700 to 2200 F before they enter the first reduction step, and the gas is preheated to about 1300 to 1600 F before it enters the third step. In the first step the reaction temperature is about 1300 to 1550 F, and in the second and third steps about 1050 to 1300 F, which temperatures can be maintained without sticking.

The product discharging from the first step (predominantly FeO)

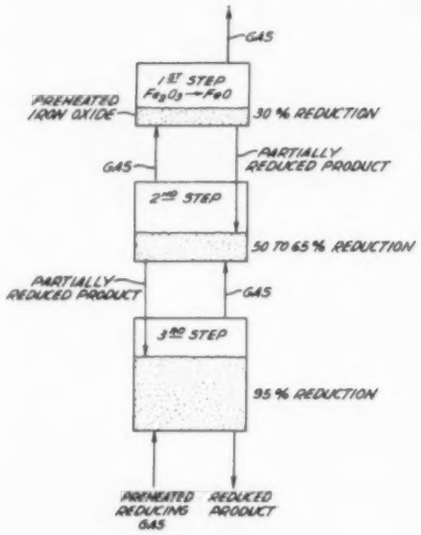


Figure 9

is about 30 per cent reduced, assuming the feed to be Fe_2O_3. The reduction which takes place in the second and third steps is apportioned so that the heat requirements of these steps approach equality. Such control is effected by regulating the relative residence time or depths of the beds of fluidized solids in the two steps.

ORE REDUCTION

△ U. S. 2,997,383, issued Aug. 22, 1961 to Thomas H. Whaley and assigned to Texaco Development Corp., provides a process for reducing iron oxide in two stages, whereby the oxide is only partially reduced in an initial reducing zone using a hot mixture of carbon monoxide and hydrogen, after which reduction is completed with hydrogen alone.

As shown in Figure 10, an oxidic iron ore is fed into an initial reducer 11 from a supply hopper 13. The ore may range in particle size from small lumps to fine powder. As the ore passes down through the reducer 11, it encounters upwardly flowing hot reducing gases comprising a mixture of hydrogen and carbon monoxide supplied to the bottom of the reducer by a conduit 15. These gases are initially at a temperature between 1800 and 2500 F. The temperature of the ore in the reducer is kept between 1100 and 1750 F during reduction effecting reduction in the solid state without fusion or sticking of the particles.

When the ore reaches the bottom of reducer 11, it is partially reduced, say to an iron content of 80 to 90 per cent by weight. It is then discharged as a finely divided solid through a conduit 17 and divided into two portions, one portion passing to a final reducer 19 and another portion passing to a reoxidizer 21.

In the reoxidizer 21, the hot, partially-reduced ore flows downwardly countercurrently to an upwardly flowing stream of steam which is supplied to the bottom of the reoxidizer by a conduit 23. In the reoxidizer 21, the temperature is maintained between 1400 and 1700 F without external heating. The steam reacts with the partly reduced ore in accordance with the following equations to partially reoxidize the metal and produce hydrogen:

$$Fe + H_2O \rightarrow FeO + H_2$$

$$2FeO + H_2O \rightarrow Fe_2O_3 + H_2$$

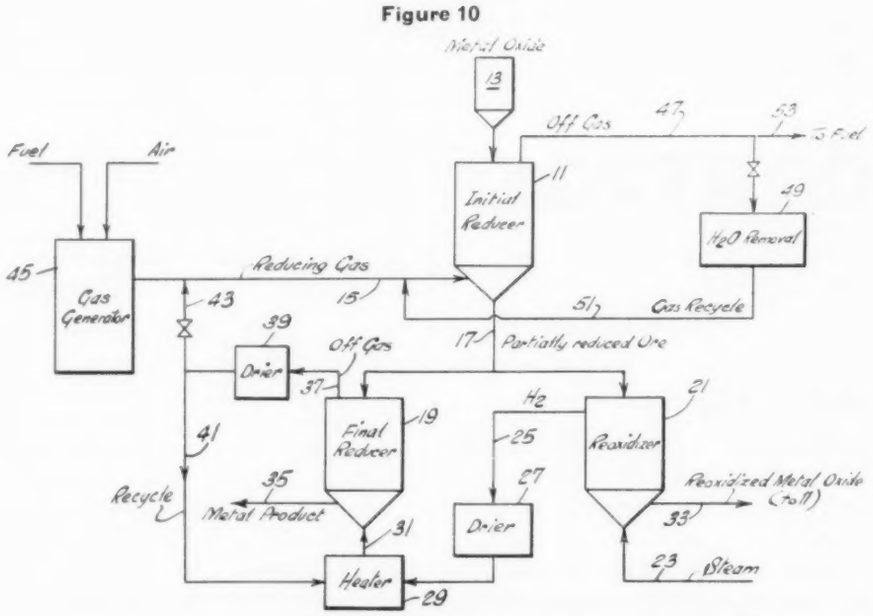
Hydrogen leaves reoxidizer 21 by way of a conduit 25, passes through a drier 27 and then through heater 29 from which it is then passed through a conduit 31 into the bottom of the final reducer 19. In heater 29 the hydrogen is heated to a temperature between 900 and 1800 F. Partially-reoxidized ore from the bottom of generator 21 is withdrawn through a conduit 33 and recycled back to the initial reducer 11 as part of the feed.

In the final reducer 19, hot hydrogen passes countercurrently to the downwardly flowing partially-reduced ore and completes the reduction in the solid state so that iron oxide is converted in the range 700 to 1400 F to a metallic product of the desired degree of reduction. The temperature is maintained as high as possible within this range without fusion or agglomeration of the ore particles or iron product. This iron product, which may be 90 to almost 100-per cent metallic iron, is then withdrawn from the bottom of the reducer through a conduit 35. Unreacted hydrogen leaving the top of the final reducer 19 passes through a conduit 37 and through a drier 39, and is then recycled through a line 41 to the heater 29 where it joins the hydrogen from reoxidizer 21. A purge stream of hydrogen can be passed through a conduit 43 into the conduit 15 which carries hydrogen and carbon monoxide to the initial reducer.

The mixture of hot hydrogen and carbon monoxide forming the initial reducing gas in the line 15 can be obtained in any desired manner. Preferably this mixture is generated in a gas generator 45 by the partial oxidation of a hydrocarbon, such as natural gas, fuel oil or crude petroleum residue, using air as the oxidizing medium.

The efficiency of reducing gas utilization may be increased by recycling part of the gas leaving the top of initial reducer 11 through line 47. Recycle gas passes through water remover 49 and then through a line 51, into reducing gas line 15 and into the reducer. The balance not required for recycle passes through line 53 to be used as fuel for other parts of the process, e.g., for the heater 29 and for generating steam supplied through line 23.

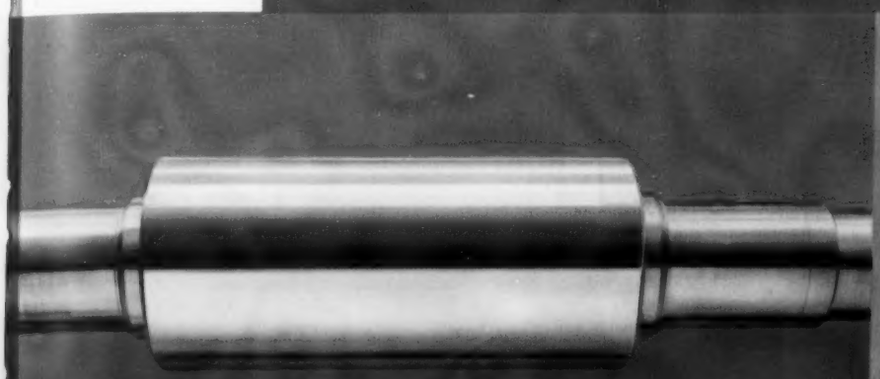
Figure 10



Steel

for Strength
. . . Economy
. . . Versatility

Vacuum-degassed forged steel back-up roll



Vacuum-degassed hardened steel work roll

Forged steel back-up roll sleeve

Cast iron back-up roll sleeve

NEW!

Bethlehem iron sleeves for temper mills

Bethlehem cast iron back-up roll sleeves have proved themselves for over six years in Bethlehem's own temper mills. Now we're making them available to everybody. They're an important addition to our line of top-quality rolls and sleeves for temper and cold-reduction mills.

BETHLEHEM STEEL

BETHLEHEM STEEL

Pouring iron for sleeve into chill mold.

GET MORE TONNAGE FROM TEMPER MILLS

with Bethlehem cast iron back-up roll sleeves

Over the past six years, we've produced many of these iron sleeves for our own temper mills. They've averaged 340 per cent more tons production on sheet temper mills than previous sleeves . . . 300 per cent more tons production on tin temper mills. Not one has split. Not one has slipped.

Grinding bore of cast iron sleeve.

Most rolling mill people agree that *iron* back-up rolls on temper mills produce more tonnage than any other kind of rolls. Practically all blackplate, and tinplate mills use them; so do many sheet mills. Since there's less "build-up" on iron rolls, you don't have to grind as often (which cuts downtime) . . . or remove as much per grind (which lengthens service life).

But not everyone agrees on which kind of iron back-up roll to use. The *one-piece* cast iron back-up roll? Or the cast iron back-up roll *sleeve*?

The iron sleeve gets our vote

Back in 1955, Bethlehem pioneered the development of a cast *iron* sleeve mounted on a *steel* arbor. This combines the best of both—the best possible working surface with the best possible

Grinding steel arbor with shrink allowance.

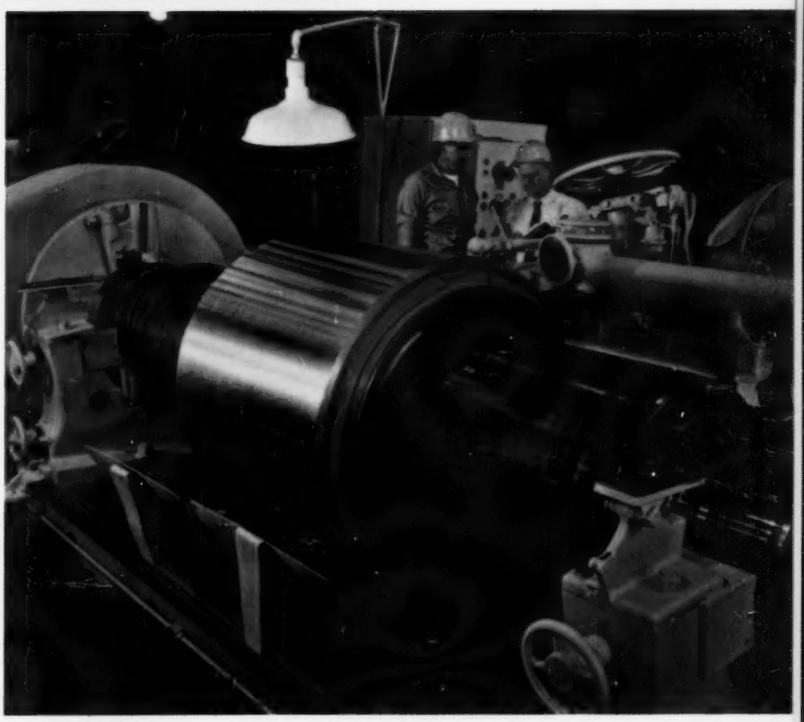
Here the holding device with cast iron sleeve is being lowered onto steel arbor. Sleeve is first heated to about 500 deg in order to expand bore. Then it is lowered, as shown. When the sleeve cools and contracts, it forms a tight "shrink fit."

neck strength. It's also a lot less expensive to mount a cast iron sleeve on an existing steel arbor than it is to buy a new one-piece cast iron back-up roll.

But let us hasten to add that if you now use one-piece cast iron back-up rolls, *and have found the neck strength adequate*, you've also got a fine opportunity to re-sleeve with a Bethlehem iron sleeve. And at a nice savings, too.

Fast delivery . . . attractive prices

You can count on good delivery of Bethlehem iron sleeves. And the price is right. For more information about Bethlehem cast iron back-up roll sleeves—and how they increased production on our own temper mills by 300 per cent and more—call or write the Bethlehem sales office nearest you. Or write to us at Bethlehem, Pa.



Finish grinding of the cast iron roll sleeve-and-arbor assembly.

BETHLEHEM STEEL

BETHLEHEM STEEL

TOP-TONNAGE TEAM FOR TEMPER MILLS

Bethlehem cast iron back-up roll sleeve

In our own mills, they've averaged 340 per cent more tons on sheet temper mills than previous sleeves . . . 300 per cent more tons on tin temper mills.

BETHLEHEM VACUUM-DEGASSED HARDENED STEEL ROLL

Bethlehem vacuum-degassed hardened steel work roll

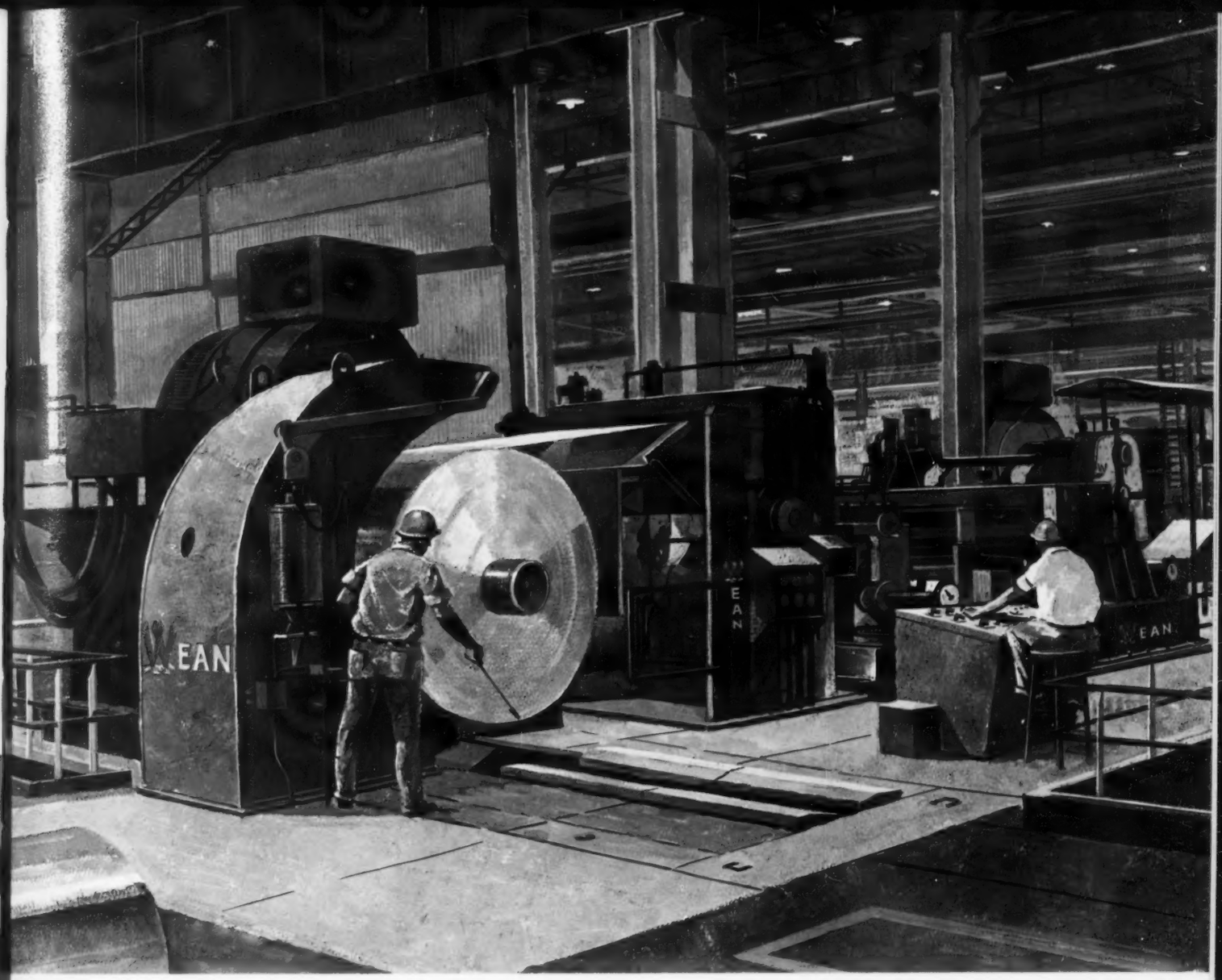
These hardened-and-ground forged steel rolls minimize the hazard of roll breakage, increase production. Forged from vacuum-degassed steel . . . from steel that is sounder, tougher, and cleaner than air-cast steel. Deliveries are excellent. And there's no price extra!

BETHLEHEM STEEL COMPANY,
BETHLEHEM, PA.

Export Sales:
Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL



PORTRAIT OF PROGRESS: *Wean Coil Preparation Line at Weirton Steel Company, Division of National Steel Corporation*

Weirton Increases Efficiency of Tinning with Wean Coil Preparation Line

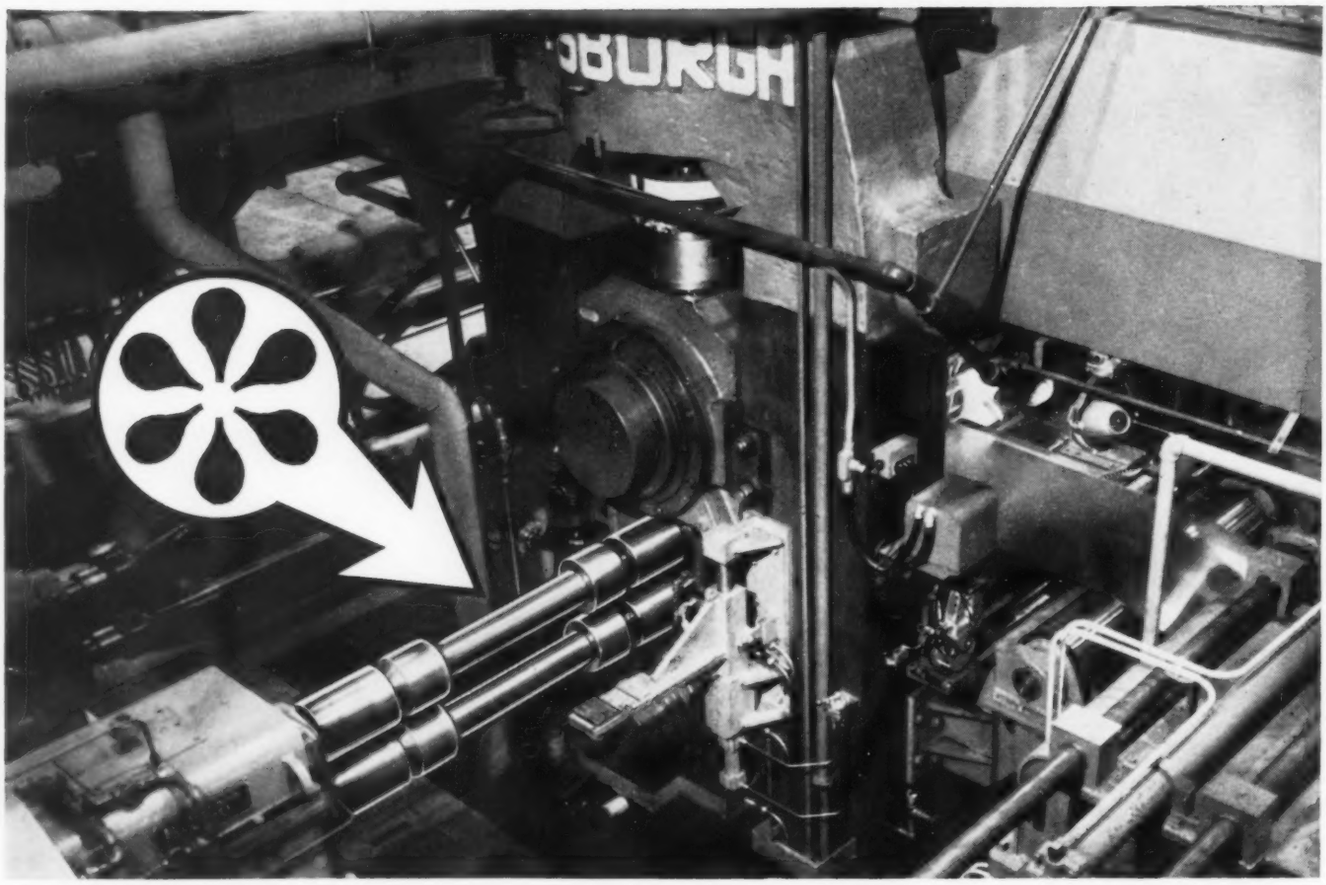
The trend toward purchase of tin plate in coil form has placed increased emphasis on the production of uniformly high quality coils. To assure this uniformity in the end product, Weirton Steel Company has installed this high-speed Wean side-trim and recoil line to prepare coils for the tinning operation. The line side trims tin plate stock and builds up larger, more evenly wound coils for more efficient operation of the tinning lines.

This tension-type line has a maximum speed of 4,000 fpm and is able to handle 60,000 lb. coils 18″ to 45″ wide. Maximum inside diameter of the coils is 16½″; outside diameter, 85″.

More efficient continuous coil processing has been the primary goal of Wean's engineering research for over 30 years. Why not use modern Wean technology to help you in increasing the efficiency of your continuous processing facilities.

THE WEAN ENGINEERING COMPANY, INC. · WARREN, OHIO

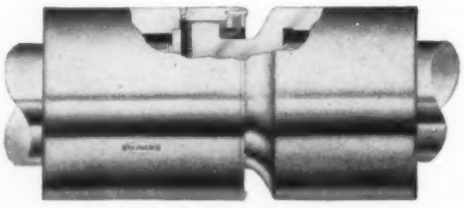
Miles of Sheet Rolled on Mill Driven by



AJAX Dihedral Spindle Couplings

Around the clock production of tons of Anaconda Aluminum sheet depends on Ajax Dihedral Spindle Couplings delivering the power to this mill built by Pittsburgh Engineering & Machine division...*a Textron Company.*

They are driving this 12x38x66 four-high cold mill *at Anaconda Aluminum's Terre Haute plant* and turning out miles of sheet with accurate gauge and thickness and excellent surface finish.



The ability of Ajax Dihedral Spindle Couplings to handle various offset and angular requirements at constant peripheral speed has established new standards of output and quality control.

As this on-the-job photograph shows, Ajax sealed-in lubrication insures good housekeeping in the shop as well as long life performance.

Hundreds of Ajax Dihedral Spindle drives are increasing production and cutting maintenance costs in mills throughout the world.

Mill builders and mill owners are invited to take advantage of our broad experience gained in designing couplings for a wide variety of ferrous and non-ferrous mills. Consult the yellow pages or write for Bulletin 70.

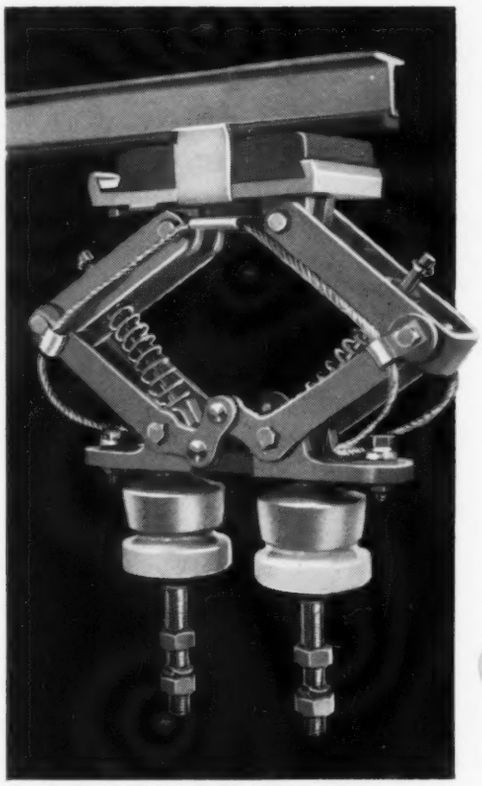
AJAX FLEXIBLE COUPLING CO. INC.

20 PORTAGE ROAD WESTFIELD, NEW YORK

Incorporated 1920

In Canada—The Alexander Fleck Ltd., Ottawa

C.A.B.R.A. AWARD for outstanding applications of copper in industry this year went to Ringsdorff Carbon Corp. current conductor system's extruded copperhead rail.



The heart of the Ringsdorff Current Conductor System — the copperheaded steel conductor rail and pantograph current collector with a graphite carbon shoe. Components, including rail hangers and joints, are available in a wide variety of sizes, with capacities up to 2000 amps, for either a-c or d-c systems.

More Plant Engineers Specify . . .

RINGSDORFF

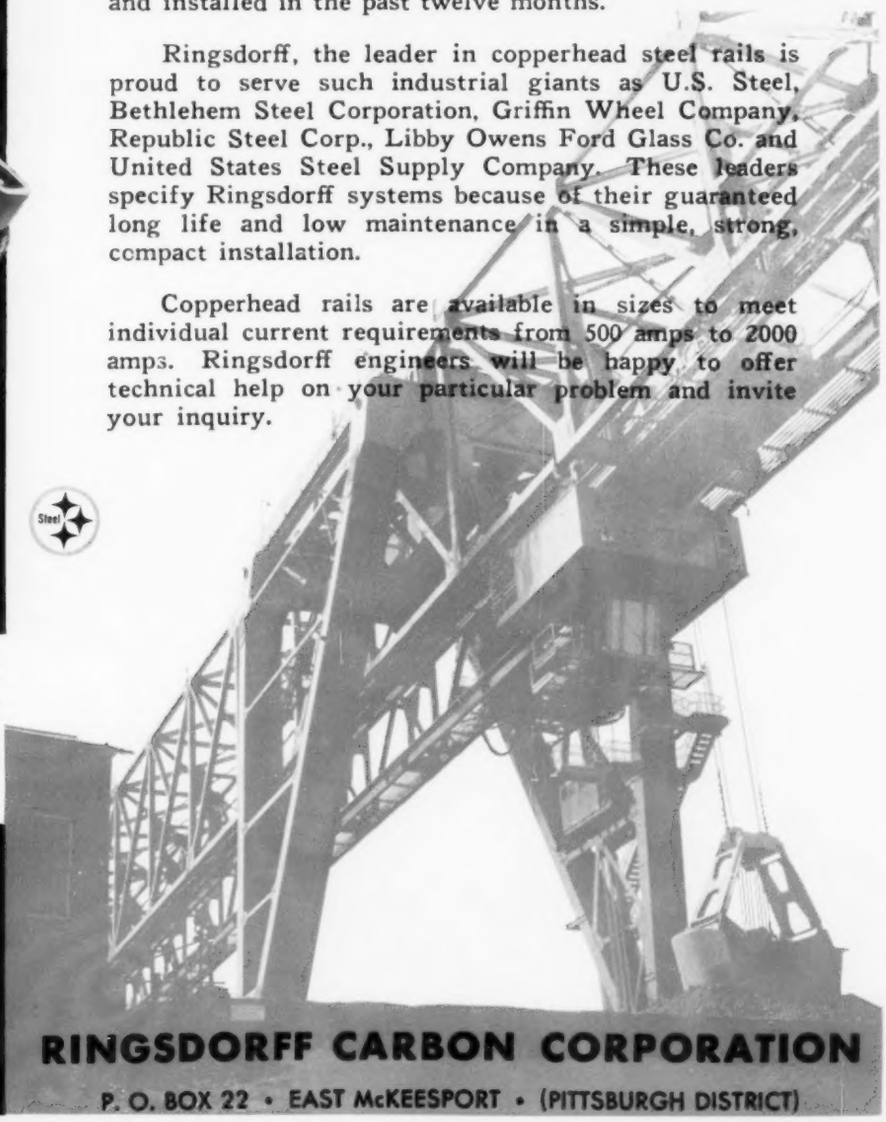
COPPERHEAD STEEL CONDUCTOR RAILS

working for industry in a compact, low maintenance conductor system for heavy current applications!

The only U.S. manufacturer of copperhead steel conductor rails, Ringsdorff now provides America's leading industrial users of travelling cranes, ingot buggies, ore bridges, and other electrified equipment with both AC and DC systems. OVER 60,000 FEET of Ringsdorff copperhead steel conductor rails were specified, delivered and installed in the past twelve months.

Ringsdorff, the leader in copperhead steel rails is proud to serve such industrial giants as U.S. Steel, Bethlehem Steel Corporation, Griffin Wheel Company, Republic Steel Corp., Libby Owens Ford Glass Co. and United States Steel Supply Company. These leaders specify Ringsdorff systems because of their guaranteed long life and low maintenance in a simple, strong, compact installation.

Copperhead rails are available in sizes to meet individual current requirements from 500 amps to 2000 amps. Ringsdorff engineers will be happy to offer technical help on your particular problem and invite your inquiry.

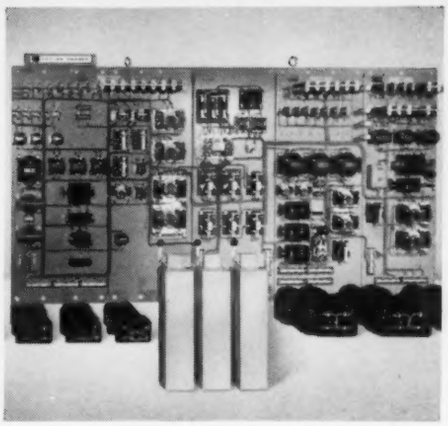


RINGSDORFF CARBON CORPORATION

P. O. BOX 22 • EAST McKEESPORT • (PITTSBURGH DISTRICT)

WHAT'S NEW
IN
A-C REACTOR
CRANE CONTROL?

American Hoist & Derrick Company's large 50-ton revolving crane at Port of Milwaukee features Cutler-Hammer's new a-c reactor crane control.



Reactor Control integrated panel for three-motion crane is shown above. Notice advantages of convenient front wiring in Cutler-Hammer's new steel panel system.

CONTROL

New! Get the right a-c control for your crane from Cutler-Hammer

Which of these a-c reactor control features will solve your problems?

☐ *Static* ☐ *Stepless* ☐ *Float Control* ☐ *Cushioned Starting*

To meet your most demanding needs for reactor crane control, Cutler-Hammer can supply a variety of combinations — all static and static-contactor types.

These lab and field tested options make it possible to tailor the control to the crane's working conditions . . . very important to satisfactory performance of a-c reactor controlled cranes.

CHECK THESE CUTLER-HAMMER FEATURES

- **Reactors** feature grain oriented laminated "C" cores and aluminum strip wound power coils. Entire reactor is dipped in a polyester resin to mold the various parts into a unified mass and provide permanent moisture seal.
- **In primary systems,** all four reactors are identical to simplify parts inventory. In secondary reactor controllers, three identical reactors are supplied.
- **Panels** are all front connected steel. All control and power connections are brought to terminal boards. Rear access is unnecessary.
- **Pre-amplifiers,** where used to obtain speed regulations, are static magnetic so static feature is preserved.
- **Unit panels.** Various control functions are grouped for ease of trouble-shooting and maintenance.

CUTLER-HAMMER REACTOR CRANE CONTROL

Reactor Control	Primary Components	Bulletin Number	Secondary Components	Master Response	Application
Secondary	Reversing Contactors	14180	Controlled Reactors and Resistor	Torque	Reversing Plugging Bridge or Trolley Drive
		14181	Controlled Reactors and Resistor	Speed	Reversing Plugging Bridge or Trolley Drive
		14182	Controlled Reactors Resistor & Contactors	Speed	Counter-torque Hoist
Primary	Primary Magnetic Amplifiers	14186	Resistor / Resistor and Fixed Reactor	Torque	Reversing Plugging Bridge or Trolley Drive
		14187	Resistor / Resistor and Fixed Reactor	Speed	Reversing Plugging Bridge or Trolley Drive
		14188	Resistor and Fixed Reactors	Speed	Static Reversing Hoist Drive
		14189	Resistor and Two Contactors	Speed	Reversing Hoist Drive

WHAT'S NEW? ASK . . .

CUTLER-HAMMER

Cutler-Hammer Inc., Milwaukee, Wisconsin • Division: Airborne Instruments Laboratory • Subsidiary: Cutler-Hammer International, C. A. • Associates: Cutler-Hammer Canada, Ltd.; Cutler-Hammer Mexicana, S. A.

CONTROL

OXYGEN
GOOD FOR STEELMAKING– BAD FOR REFRACTORIES

Since the beginning of oxygen steelmaking in North America, Harbison-Walker has contributed to the success of the processes through the development of several entirely new refractories, and the improvement of others to give them longer life under the more severe conditions that accompany oxygen operations.

FOR THE BASIC OXYGEN PROCESS: Harbison-Walker developed entirely new types of refractories. These products—OXILINE H and OXILINE CL tar-bonded brick, and H-W OXIMIX—hold many production records, and are firmly established as standards of the industry. Harbison-Walker is the only manufacturer who has supplied linings to all basic oxygen process shops on the North American continent.

IN OPEN-HEARTH FURNACES: The introduction of high volumes of oxygen speeds the refining process, but also adds materially to the wear and tear on refractories. To withstand these severe conditions, Harbison-Walker developed a high purity (over 98% MgO) high density magnesite from which to produce special METALKASE refractories for the most vulnerable parts of the furnace. These new refractories will augment the present superior life of such well known products as EXKASE MAGNEX OHR, METALKASE MAGNEX H, H-W PERIKLASE and the monoliths H-W C-MIX and H-W GUNSHOT, and will continue to aid steelmakers in maintaining the high production rates that the oxygen lance makes possible.

These Harbison-Walker products, representing today's most-advanced practices, are being constantly improved through the use of better raw materials, closer quality control and continuous studies of operating experience.

HARBISON-WALKER REFRACTORIES COMPANY AND SUBSIDIARIES

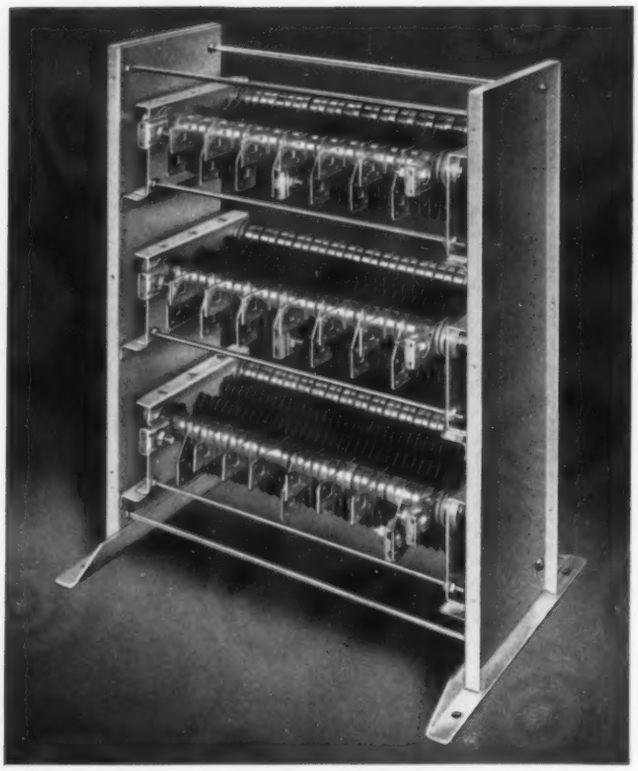
GENERAL OFFICES: Pittsburgh 22, Pa.

World's Most Complete Refractories Service

HW 61-24

POST-GLOVER RESISTORS...

Racked to suit the application!



Plain Racks without enclosure

Racks with solid or expanded metal tops

Racks with louvered or expanded metal sides

P-G Resistor Racks are available for all P-G Resistors in units from two to eight resistors high. If other than standard racks are more suitable, special racks can be furnished to suit the application. Ventilation is achieved through louvered or expanded metal panels as desired, both easily removable with only a screw driver. P-G Racks may be shipped complete with resistors mounted, with or without enclosure, or knocked down to save shipping space. For further data about P-G Resistors and Racks, write us of your needs.

P-G the ORIGINAL Steel Grid Resistor

Made of steel and mica, nothing to break, plus P-G unique and exclusive grid design, these resistors afford maximum protection to vital equipment. They are rugged, nonbreakable, shock resistant, and have proved their merit in all kinds of service for over 20 years.

The Nonbreakable Steel Grid Resistor

P-G

ESTABLISHED 1892

THE **POST-GLOVER** ELECTRIC COMPANY

OFFICE and FACTORY—Kenton Lands Road, Erlanger, Kentucky

MAILING ADDRESS—Box 709, Covington, Kentucky

PLAYING FOR BIG STAKES IN THE CAN MARKET, KAISER ALUMINUM FINDS A . . .

NEW WAY TO CUT, DEAL AND STACK THE DECK

Into aluminum's battle for the can market, Kaiser Aluminum & Chemical Corporation has just introduced a formidable new weapon: a shearing and classifying line that runs as fast as the fastest lines currently used by the steel industry for tinplate. ■ In effect, the new line obsoletes existing aluminum can stock cut-up lines. Operating on light gages of aluminum, these older lines have a top shearing and piling speed of 350 feet per minute. Classifying is a separate operation. The new line, designed and built by Bliss' Rolling Mill Division, shears, classifies and piles in a single, continuous operation at speeds up to 600 feet per minute. ■ Starting with coils of aluminum strip up to 42″ wide and weighing as much as five tons, the Bliss line levels the strip, automatically checks it for variations in thickness, shears it into accurately-sized sheets, and classifies the metal. Down time for coil changing is all but eliminated by a specially-designed coil entry turnstile, which readies a coil for mounting on the entry payoff reel while the preceding coil is paying off into the line. Moreover, there are two "prime" stacks at the delivery end, so that one can be removed while sheets are feeding onto the other. ■ Located at Kaiser Aluminum's Trentwood, Wash., plant, the new classifying line is an outstanding example of how Bliss can engineer equipment for special requirements. For other examples of Bliss installations in the plants of basic metal producers, write us for a complimentary copy of our 84-page Rolling Mill Brochure, Bulletin 40-B.

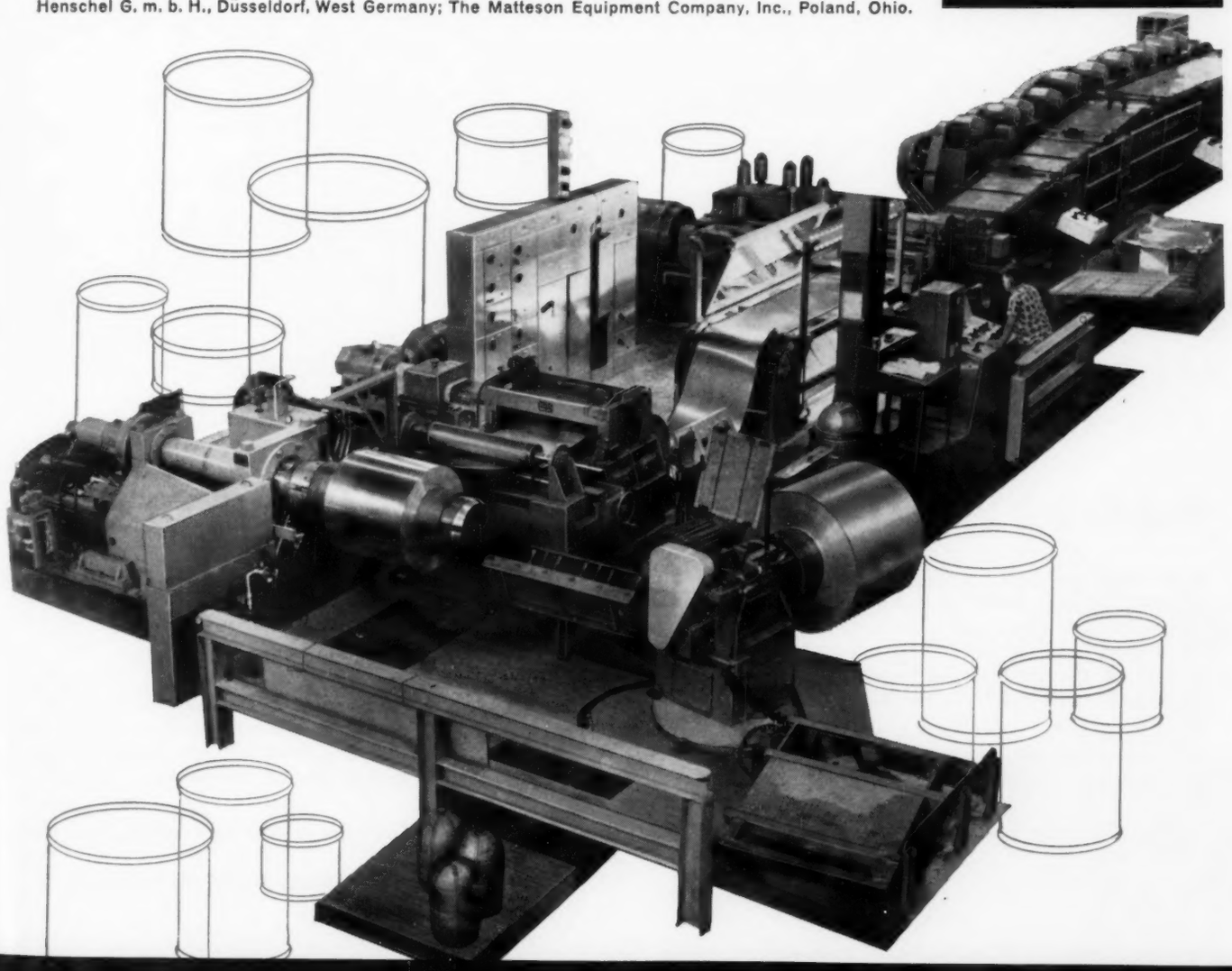
Bliss is more than a name...it's a guarantee

E. W. BLISS COMPANY, Rolling Mill Division, Salem, Ohio

Rolling Mills • Mill Auxiliaries • Amerigear/Bliss Flexible Spindles

Subsidiaries: E. W. Bliss (Canada) Ltd.; E. W. Bliss (England) Ltd.; E. W. Bliss Co. (Paris) France; E. W. Bliss-Henschel G. m. b. H., Düsseldorf, West Germany; The Matteson Equipment Company, Inc., Poland, Ohio.

BLISS
SINCE 1857 ®



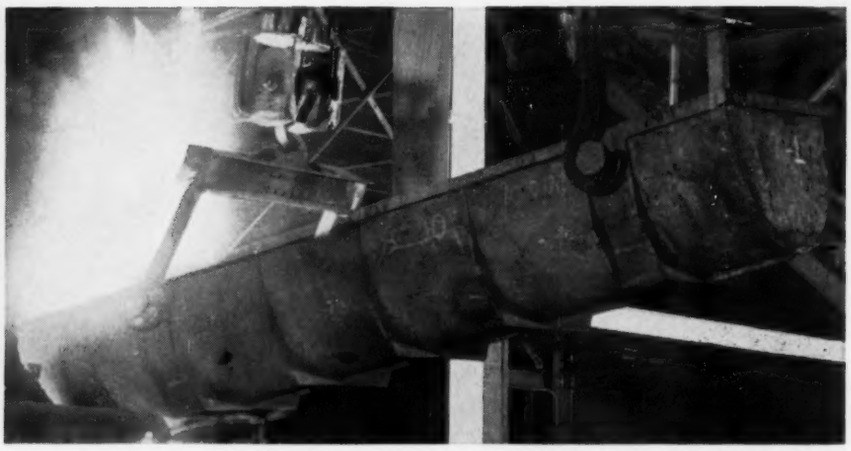
In a cubicle near the converter, an operator closely follows the progress of a blow. These Honeywell instruments indicate, record and control such variables as oxygen mass flow, lance cooling water temperature and pressure, lance position, and hood temperatures.

Honeywell-controlled BOF process

Acme Steel used to buy semi-finished steel slabs and billets to produce rolled strip, floor plate, strapping and other finished steel products. When limited supply threatened to block the company's potential growth, it turned to the basic oxygen furnace process as the economical method of producing its own steel.

Now, Acme's Chicago mill can produce a 75-ton heat of steel every 40 minutes with its new Honeywell-controlled oxygen process. Two continuous-flow hot blast cupolas are teamed with two oxygen converters to make many types of steel in small batches, at low cost per ingot ton.

The flexibility and economy of the mill's oxygen process stem largely from a carefully-engineered control system. Honeywell instrumentation accurately meters high-purity oxygen, maintains efficiency of the converter blow, protects equipment from excessive temperatures and guards safety of operating personnel.



Using a basic charge of about 80 percent molten iron and 20 percent scrap, Acme Steel's oxygen converters produce high-grade steel at low cost. About 2,000 cubic feet of high-purity oxygen is required for each ton of steel.

makes Acme Steel its own supplier

If you're planning to use oxygen—in a BOF or open hearth—you'll find it profitable to have Honeywell design your entire control system, tailored to the particular requirements of your mill. Your nearby Honeywell field engineer can give you full details. Call him today—he's as near as your phone.

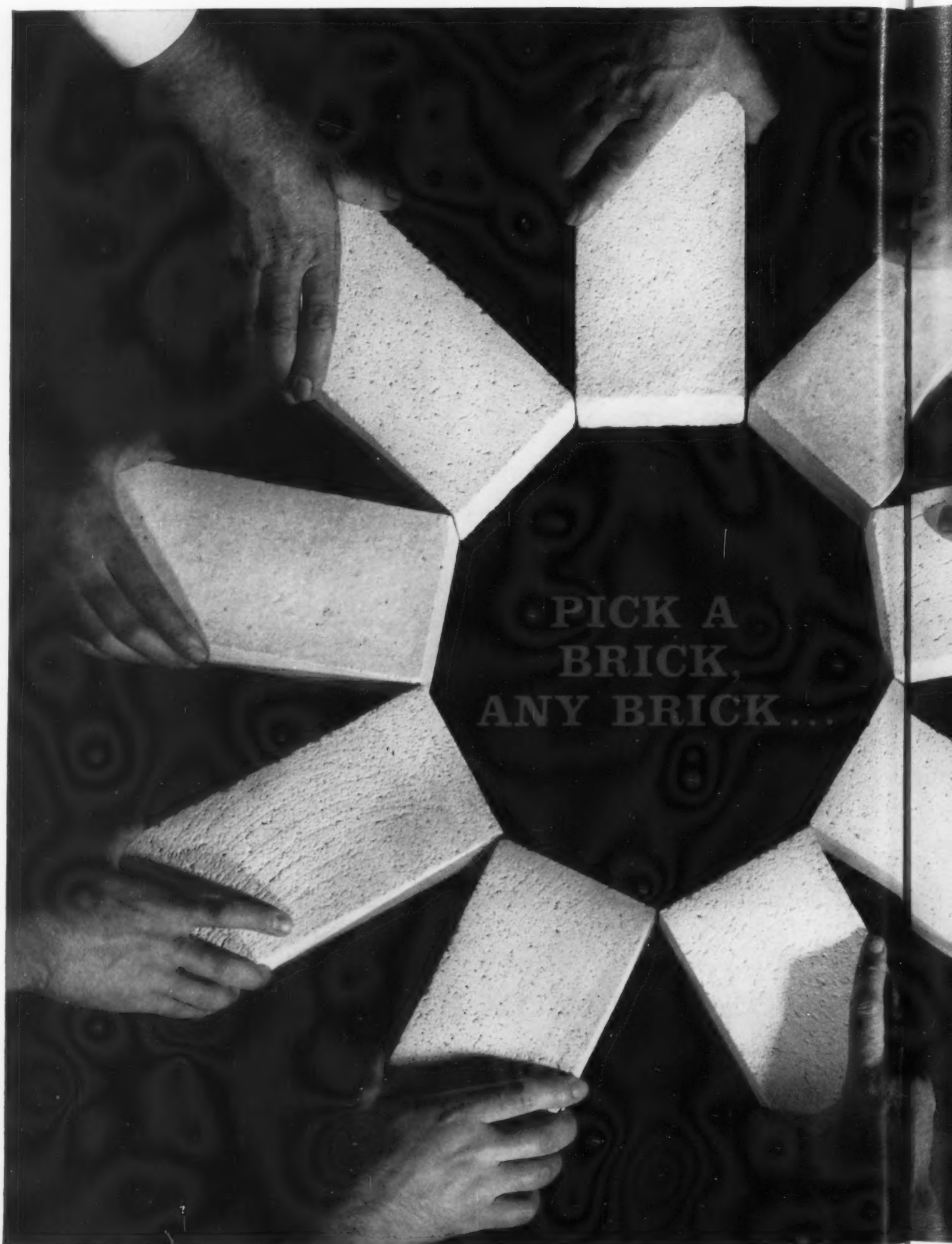
MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa. In Canada, Honeywell Controls, Ltd., Toronto 17, Ontario.

Honeywell

First in Control

SINCE 1885

HONEYWELL INTERNATIONAL Sales and Service offices in all principal cities of the world. Manufacturing in United States, United Kingdom, Canada, Netherlands, Germany, France, Japan.


PICK A
BRICK,
ANY BRICK...

Whichever insulating fire brick you need... J-M has it!

...INCLUDING THE IMPROVED AND ACCEPTED PREPARED-ATMOSPHERE BRICK – JM-23 AND JM-20

Now, from one manufacturer, you can get whichever insulating fire brick offers you the most economical and efficient control of heat! Johns-Manville produces nine in all, covering temperatures up to 3000F. They have been developed to provide you with the proper insulating fire brick for any given service.

THE IMPROVED JM-23 AND JM-20 are ideal for use in prepared-atmosphere furnaces and for a wide variety of other uses. They are designed for direct exposure or back-up insulating and are resistant to gases such as CO, H_2, and CH_4. They have the perfect balance of chemical and physical properties for effective heat control in prepared atmospheres. Most important of all, JM-23 and JM-20 offer:

- **HIGH PURITY** – These brick are made from carefully selected materials which have an extremely low iron oxide content.
- **LIGHT WEIGHT** – The improved JM-23 weighs about ⅓ less than insulating fire brick previously available in its temperature range.
- **HIGH STRENGTH** – Both brick have high cold-crushing and hot-load bearing strength.
- **HIGH INSULATING VALUE** – Both brick have an extremely low thermal conductivity.

Let J-M supply you with insulating fire brick and you can avoid delays and enjoy all the economies of buying from one source.

On your request we will send you a reprint of an editorial article on the unique process used by Johns-Manville in producing insulating fire brick. Write to J. B. Jobe, Vice President, Johns-Manville, Box 14, N. Y. 16, N. Y. In Canada: Port Credit, Ont. Cable: Johnmanvil.

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PRODUCER OF THE MOST EXTENSIVE LINE OF INSULATING FIRE BRICK

DE LAVAL

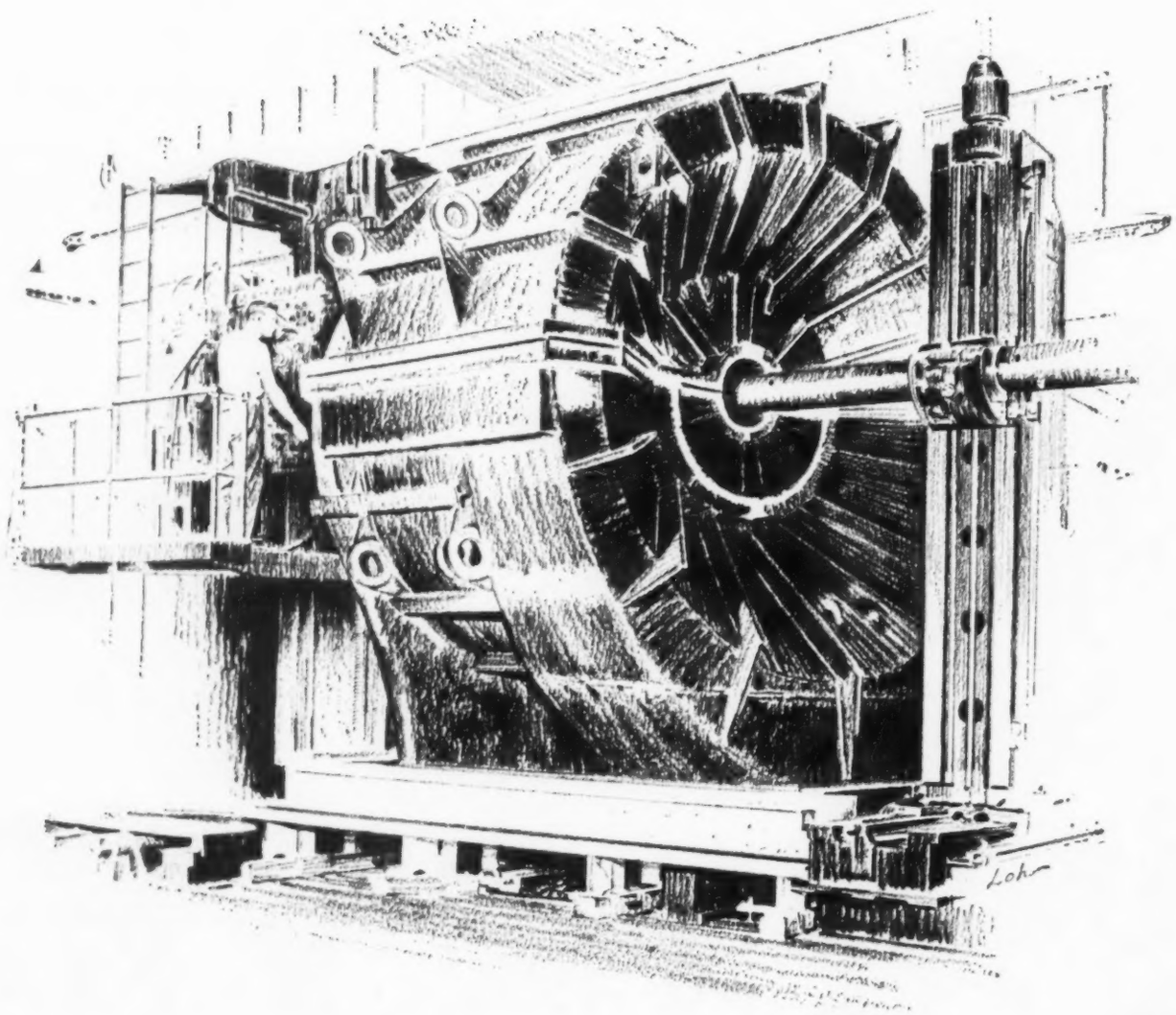
creative engineering helps boost steel output

Bigger blast furnaces offer economy to the steel industry . . . and a challenge as well. Could engineers boost the size, pressure, and efficiency of the blowers which supply combustion air and still maintain the desirable operating characteristics and rugged construction of centrifugal blower design?

The De Laval answer is this new, high-efficiency centrifugal blower for capacities up to 175,000 cubic feet of air per minute . . . an increase of 40% over previous industry standards. The all-steel casing permits an increase in discharge pressure to 50 psig.

Whether you are building bigger blast furnaces or have other problems involving rotating machinery, De Laval creative engineering can help.

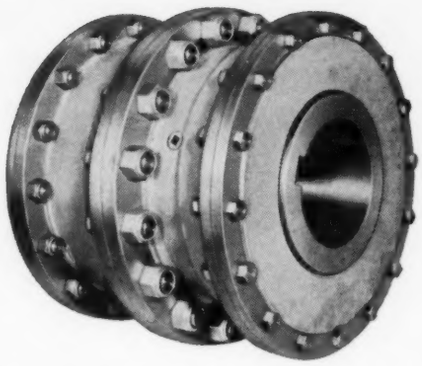
De Laval Steam Turbine Company, Trenton 2, N. J.



MG-DL-108

DE LAVAL · 60 YEARS OF CREATIVITY AND QUALITY

CENTRIFUGAL PUMPS AND COMPRESSORS • TURBINES • IMO® ROTARY PUMPS AND HYDRAULIC MOTORS
MARINE PROPULSION AND AUXILIARY EQUIPMENT • HELICAL AND EPICYCLIC GEARS • TURBOCHARGERS



Heavy duty gear type

up to 6,000 hp per 100 rpm

Here's the coupling with all the muscle you need for heavy duty slow speed mill drives. The machined surfaces of each high grade steel casting are given a fine tool finish within strict tolerances. Waldron mill type couplings are easy to assemble, and seal tight against dust, moisture, and loss of lubricant. Standard sizes, 7" to 12". Horsepower per 100 rpm, 1,282 to 6,000. Maximum rpm, 1,950 to 1,200. Write for Bulletin S-1050 to Waldron-Hartig, a division of Midland-Ross Corporation, Box 791, New Brunswick, N. J.

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NEW *Markal* **THERMOMELT TEMPERATURE INDICATORS**

With Handy Adjustable Holder

The easy modern way to determine exact working temperatures!

Just mark or stroke the surface with THERMOMELT . . . when it reaches the desired temperature, the mark liquefies. There's no guesswork, no wasted time or material . . . THERMOMELT is the quick, precise way to determine heating temperatures. Accurate to within ±1%.

A Stik For Every Temperature from 113° F. to 2000° F.

SEND TODAY for free THERMOMELT literature and pellet sample (indicate temperature desired).

ALSO AVAILABLE IN LIQUIDS AND PELLETS for inaccessible or hard-to-measure applications. Wide range of temperatures.

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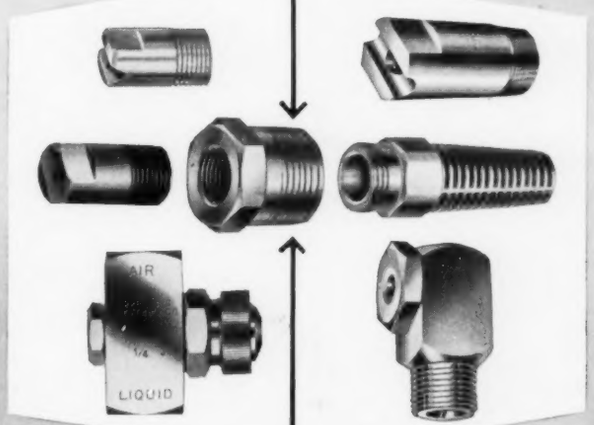
Whatever the application you will find Spraying Systems Spray Nozzles provide noticeable improvement in spraying operations . . . and often materially lower cost. Proved by performance. Supplied in a complete choice of types and capacities for selection of spray characteristics exactly as needed. Your inquiry is cordially invited.



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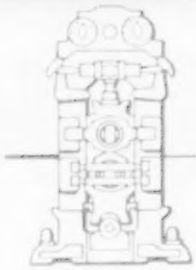
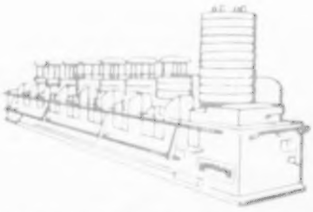
For complete information write for Catalog 24 and special data sheet folder "Steel Mill Applications".



ROLLING MILLS

MORGOIL BEARINGS



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CS4

COMBUSTION CONTROL

the
newest
development
in hot strip
mill design...

GREAT LAKES STEEL

DIVISION OF NATIONAL STEEL CORPORATION

PROVEN PERFORMANCE

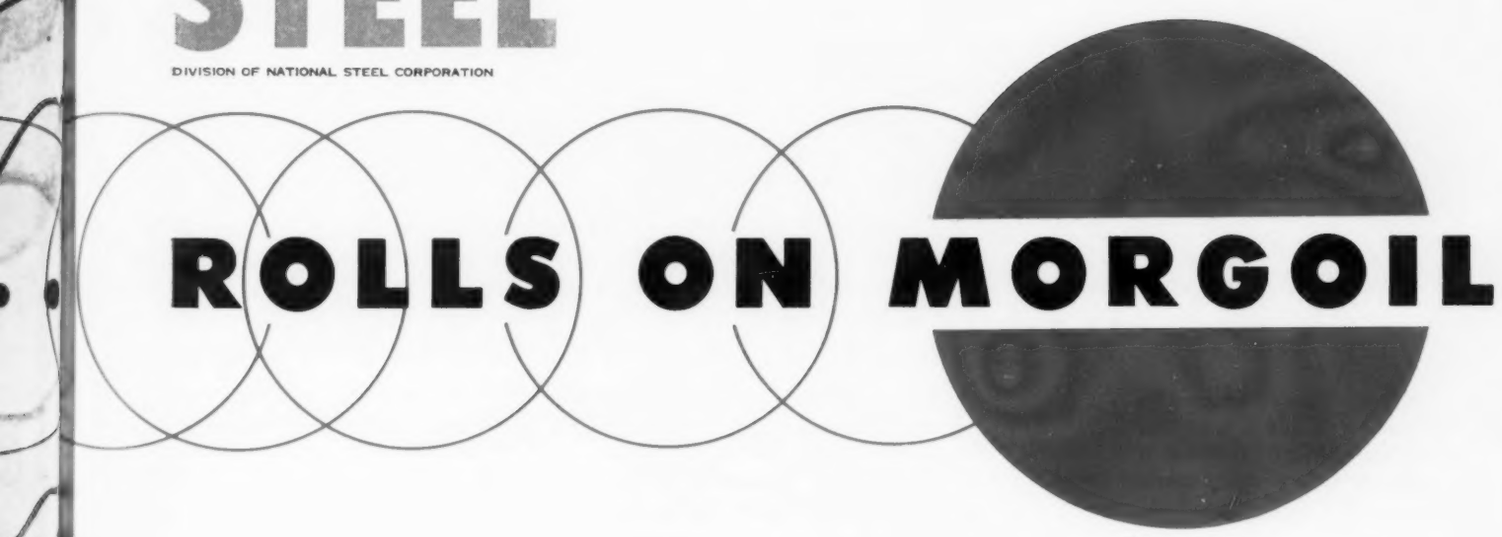
28 modern hot strip mills equipped with Morgoil Bearings since 1955 prove the soundness of Morgoil characteristics for meeting all requirements of hot strip rolling.

PRECISE STRIP

Mill stiffness is essential to precision gage control. Morgoil inherent design superiorities of unqualified capacity, high roll neck strength and chock rigidity create the stiffest possible mill without sacrificing bearing life or backup roll turndown.

LOWER COSTS

Lower over-all operating costs are a significant long-term Morgoil advantage. Lower initial costs constitute an additional sizable saving on each Morgoil installation.



OVER 19,000 MORGOIL BEARINGS NOW SERVING THE WORLD'S ROLLING MILLS

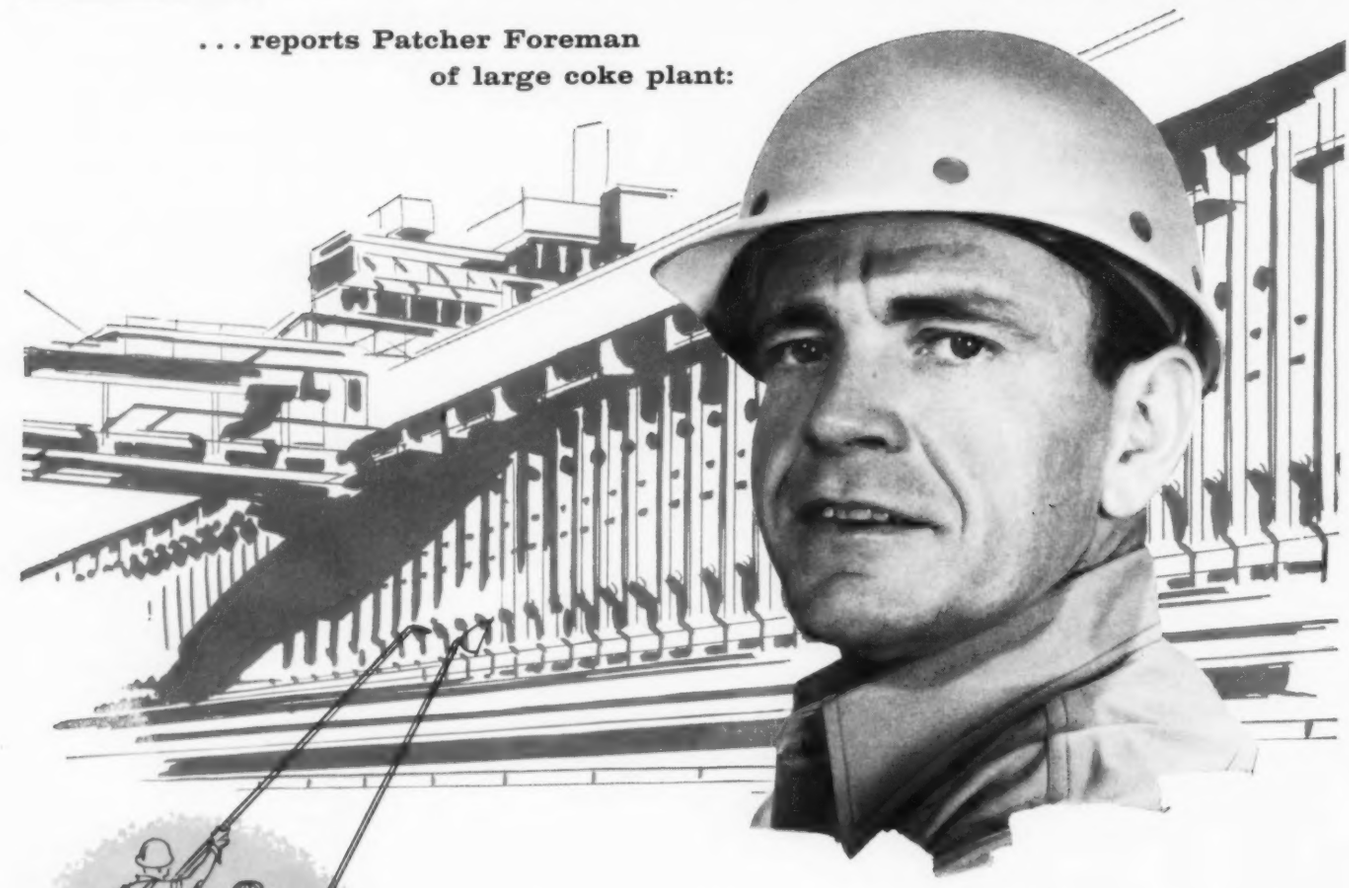
MORGAN WORCESTER

MORGAN CONSTRUCTION CO.
WORCESTER, MASSACHUSETTS

"For workability . . .

nothing matches Plibrico Spray-Tite"

. . . reports Patcher Foreman
of large coke plant:



Plibrico Spray-Tite can be gunned in place with low rebound loss. Or trowel it in place; it's highly workable.

"We are using Plibrico Spray-Tite for patching our batteries with excellent success. No other refractory mix does so complete a job."

"We gun our oven jambs with Spray-Tite and have very little rebound. We're trowelling, too, on hot walls and this material stays workable. It doesn't back up on the trowel either."

Plibrico Spray-Tite is ideal for making repairs economically without service interruptions. Use it with wet mix or nozzle mix guns, or trowel it. It bonds well, and withstands abrasion and shock. It's one of a complete line of Plibrico refractory products.

Recommended for: **Coke oven walls, jambs, charging holes Regenerator faces • Uptake pipe seals.**

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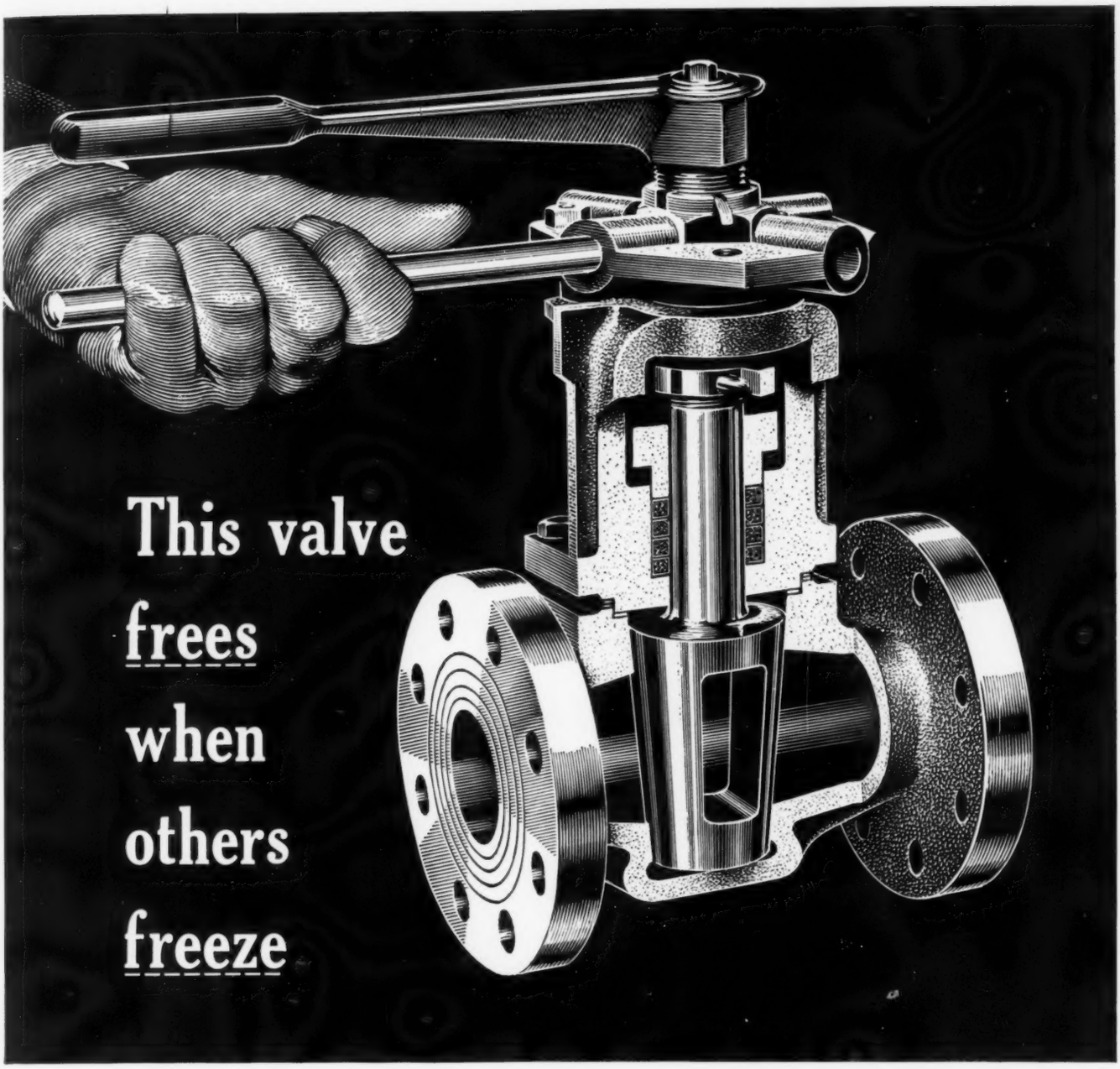
WRITE TODAY FOR LABORATORY REPORT 900-A giving complete data on properties and advantages of Plibrico Spray-Tite.



HOMESTEAD® LEVER-SEALD VALVE

It opens and shuts instantly, easily—when ordinary valves stick fast. Why? Because the Homestead Lever-Seald Valve has a positive built-in means of relieving friction and freeing the plug. Use it on lines requiring infrequent operation. Use it on lines handling slurries, viscous, caustic or corrosive fluids. Use it on lines carrying high-temperature or high-pressure fluids. Use it on lines where a lubricant is undesirable. Wherever you use it, the seats are protected from both corrosion and erosion in both open and shut positions. Under every service condition, you have positive control of the sealing or seating action for sure shutoff.

Over thirty years of demanding use prove that every Homestead Lever-Seald Valve gives long, low-cost, stick-proof control right down the line, with just a quarter of a turn. Complete facts in reference book 39-3, write for your free copy.

HOMESTEAD VALVE MANUFACTURING COMPANY
"Serving since 1892"
P. O. Box 160, Coraopolis, Pennsylvania

Makers of: Homestead® Ball Valves, Cam-Seald, Lever-Seald and Lubricated Plug Valves

Down go back-up roll costs wit

vith USS **Quality Forged Sleeves**

Pictured above is James S. Rennick, a metallurgist with twenty years' experience in the Forgings Division of U. S. Steel. Jim specifies composition, heat treatment, and other processing procedures essential to the production of assemblies as shown in the main picture—a back-up roll that will be used in the cold reduction tin mill at U. S. Steel's Gary, Indiana, plant.

This job points up a curious situation: U. S. Steel is one of the country's leading manufacturers of rolls, and also one of the biggest *users* of rolls . . . a double reason to perfect their performance and reduce their cost . . . just as we did here.

We had to replace a worn, cast steel back-up roll. Rather than replace the entire roll, we machined the face of the roll and shrunk on a *forged* steel sleeve. For back-up rolls like this one, 42″ O.D. and larger, this method of sleeving is much less expensive than buying a complete new roll. One arbor can be used for several forged sleeves. A forged sleeve has a hard, wear-resistant surface and is highly resistant to spalling.

Also, the sleeve is purposely produced with a softer bore to develop a desirable stress pattern, and to provide maximum gripping between the arbor and sleeve after assembly.

There is a good possibility that we can help reduce *your* roll costs. Write or call the United States Steel Office nearest you, or United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

United States Steel Corporation, Pittsburgh • Columbia-Geneva Steel, San Francisco • Tennessee Coal & Iron, Fairfield, Alabama • United States Steel Export Company

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USS

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OVER 1,000,000
PANALARM
ANNUNCIATORS
are in process
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More Panalarm Annunciators are specified and used because of:

Assured Reliability due to:

- 100% Inspection for all components, both in production and final assembly.
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Assured Reliability due to:

- Ultrasonic cleaning.
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- Extra safety margin for Class 1 Division 2 applications provided by electronic halogen leak detection.
- After millions of operations, max. continuous contact pressure and uniform gap spacing are assured by beryllium copper contact springs.
- Hi temp cured TEFLON-covered coils.

Panalarm maintains a large staff of annunciator engineering specialists to assist with special annunciator design and application problems. Sales and engineering offices are in all principal cities. Your inquiry will receive prompt attention.

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Annunciators • Control Panels • Data Systems

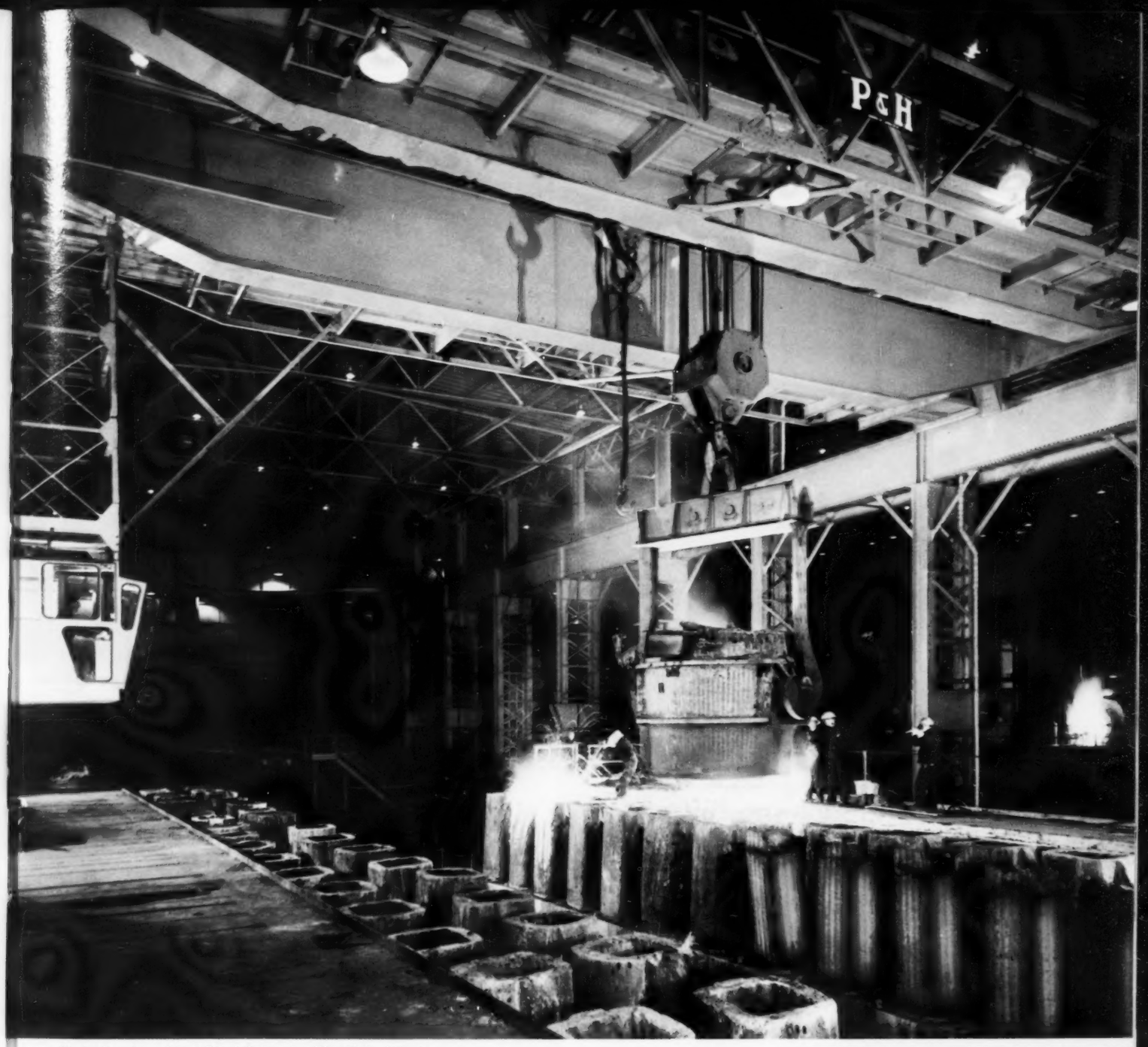


Photo Courtesy Acme Steel Company, Riverdale, Illinois.

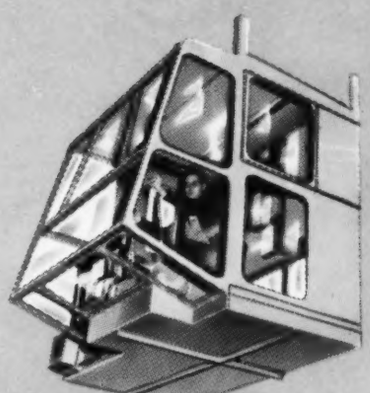
FOR EVERY APPLICATION, THERE'S ONE CRANE OUTSTANDING . . . P&H!

IN STEEL MILLS: This 100-ton P&H crane lifts, transports and "spots" tremendous loads of molten steel as surely and deftly as you handle a coffee cup.

P&H steel mill cranes perform tasks like this effortlessly and dependably because they are specifically designed for steel mill service . . . to handle massive loads, withstand searing heat, ignore frequent shock loads.

What's more, P&H carefully engineers every crane to meet specific job requirements . . . to consider all factors affecting performance. Special operating problems are taken in stride. Result: P&H cranes chalk up almost unbelievable service records month after month, year after year, decade after decade.

Isn't this the kind of performance you want, too? Write for bulletin C-42 to Dept. 120, Harnischfeger Corporation, Milwaukee 46, Wisconsin.



P&H enclosed cabs have full-view safety glass windows, for unrestricted view of work area. Cabs can be heated and air conditioned where cold, heat, smoke or fumes render ordinary cabs uncomfortable or unsafe.

Offices in major cities . . . see Yellow Pages

HARNISCHFEGER
Milwaukee 46, Wisconsin

P&H
OVERHEAD CRANES

Photo Courtesy Wacho Mfg. Co.

6000 ORDERS A DAY DON'T TIRE A ZIP-LIFT

An operator's thumb punches over 6000 commands a day into this production-line P&H Zip-Lift in a painting, coating, and tinning plant. The sturdy hoist responds promptly . . . never tires . . . and comes up asking for more.

The control pendant on a Zip-Lift operates on a safe 24-volt circuit — typical of the many safety features P&H builds into this low cost unit. There are two brakes, either of which will hold a capacity load even if power fails . . . shrouded load-block to protect workers hands . . . limit switches that guard against equipment abuse . . . and many more features that make P&H Zip-Lift hoists extra-safe and extra-dependable.

Are you guarding your personnel and your production with P&H Zip-Lifts . . . or are you going to start with your very next hoist purchase? Bulletin H20 will help you plan that purchase. It's free from Dept. 202, Harnischfeger Corp., Milwaukee 46, Wisconsin.

Offices in major cities . . . see Yellow Pages

HARNISCHFEGER
Milwaukee 46, Wisconsin

P&H
ELECTRIC HOISTS

Correct Air

CORRECT-AIR = 5

1 COOLS 2 DEHUMIDIFIES
3 HEATS 4 REMOVES DUST
5 ABSORBS FUMES AND GASES

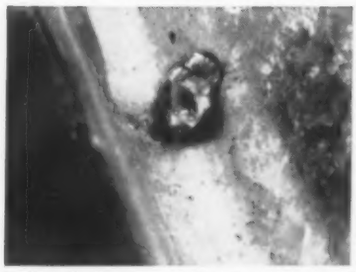
Courtesy of
Green River Steel Company

Yes, sir — or 200 degrees F. for that matter— or just about any conceivable conditions where high ambient temperatures are encountered. Absolutely without cost or obligation, we shall be glad to survey your situation in depth and present our candid findings.

CORRECT-AIR CORPORATION
WILLOUGHBY, OHIO

The Mark JCS of Quality

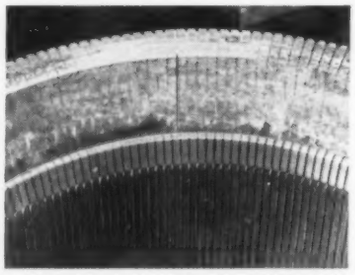
***Sold by* JAMES CAMPBELL SMITH, INC., WILLOUGHBY**
America's Largest Builders of Pulpits and Control Houses With or Without Air Conditioning



Enlarged view of a dielectric puncture of a mica vee ring at the lower end of the copper bar. This is an example of interior commutator faults which may be present though exterior appears excellent.

Shifted or squirted mica at the apex of the 3° and 30° cone surfaces of a mica vee ring. The black lines on the 3° surface were made by bar-to-bar voltage breakdown creepage.

The bar which projects above those adjacent has been locally overheated under a brush and softened.



A mica segment on the front end of the commutator has started to work out radially and will eventually result in a bar-to-bar short circuit.

NATIONAL COIL'S SERVICE INCLUDES A COMMUTATOR CHECK-UP

When repairing or re-building d-c equipment, National's specialists make a thorough commutator inspection. For example, this hardness test of the copper can pinpoint soft bars which have been overheated and need replacing.

If there is any evidence of faults, commutators are removed and opened for interior inspection. This may disclose evidence of damage from standstill burns, distorted copper and broken mica segments from overspeed, deteriorated mica and bond from overheating, weakening of V-ring mica from relative motion, causes of dielectric failure or other defects.

When having motors or generators rebuilt, it's wise to have it done by experts. For information call National's Columbus plant... HUdson 8-1151... or call the nearest National field engineer.

DIVISION OF McGRAW EDISON

NATIONAL COILS

National Electric Coil

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1962 IRON & STEEL EXPOSITION

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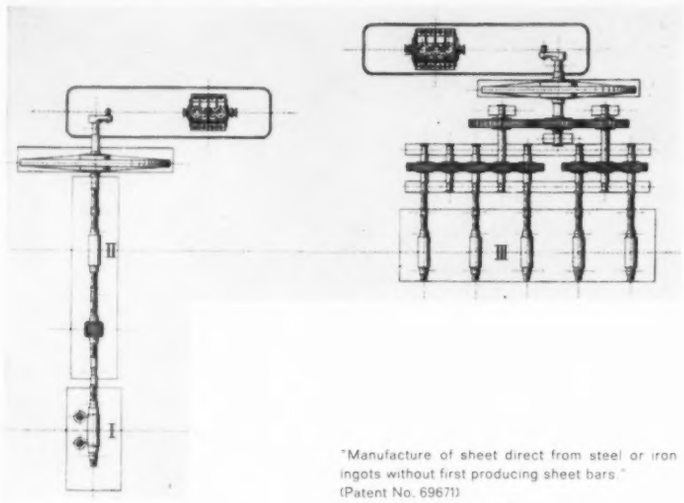
1010 EMPIRE BUILDING • PITTSBURGH 22, PA.

SEPTEMBER 25, 26, 27, 28, 1962 • CLEVELAND PUBLIC AUDITORIUM



"Manufacture of sheet direct from steel or iron ingots without first producing sheet bars." (Patent No. 69671)

1892 - The first continuous sheet mill

In 1892 the first continuous sheet mill was put into operation at the Rudolfshütte, Teplitz. The production of sheet from an ingot by continuous rolling was here made possible for the first time. "Stahl und Eisen" No. 22/1892 states: "Märkische Maschinenanstalt at Wetter/Ruhr (DEMAG's parent works) was entrusted with the construction of a mill at high costs and great risks".

This first continuous sheet mill was the starting point for numerous developments which, in 1937, led to the construction of Europe's first fully continuous wide strip mill at Dinslaken. This mill, too, was built by DEMAG.

The fund of experience available at DEMAG was fully utilized by the engineers and designers who helped build the Iron and Steel Works at Rourkela, India. Under the same contract, DEMAG was awarded the order for the supply of the first fully continuous wide strip mill in India. This mill is now in operation and supplies the sheet required by the processing industry of this aspiring, technical young country.

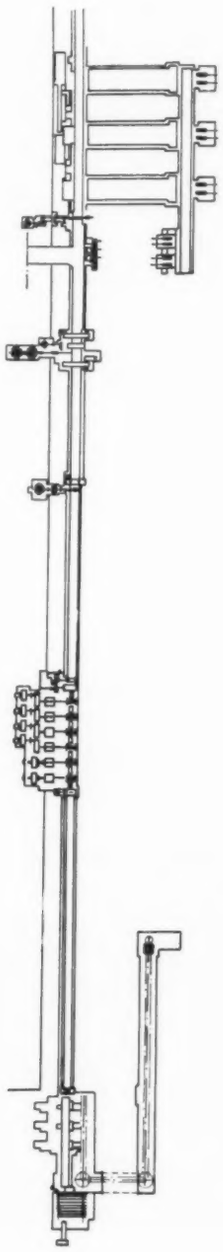
The Rourkela Iron and Steel Works was put into operation in 1961

DEMAG AKTIENGESELLSCHAFT DUISBURG GERMANY

American Demag Corporation, 375 Park Avenue, New York 22, N. Y.
One Gateway Center, Pittsburgh 22, Pa.

Three-quarter continuous wide strip mill Rourkela

The DEMAG built wide strip mill supplied to the Rourkela Iron and Steel Works is capable of rolling slabs with the following maximum dimensions: lenght 6,000 mm., width 1,550 mm., and thickness 190 mm. The guaranteed production of the mill is 1,300 tons/8 hours. It was exceeded by 22% even after only a short starting-up period. Maximum strip dimensions are 1,550 mm. wide and 1.6 to 10 mm thick. Maximum coil weight is 9 kg per mm. width with the maximum coil weighing 12 tons.



1. Two-high scale breaker

Via a roller table the heated slabs arrive at the scale breaker where they receive a reduction of about 10% to remove the scale. Pressure water is used to spray off the scale.

2. Four-high reversing roughing stand

This stand reduces the stock generally in three passes and is used for edging.

3. Four-high non-reversing intermediate stand

Slabs rolled into strip are here given a single pass to reduce them to the required thickness for entry into the finishing mill. A light duty edging stand in front of the intermediate stand prevents the stock spreading.

4. Six-stand four-high finishing mill

The strip is first cropped and, after passing the descaler, enters the six stands of the finishing mill for finish-rolling.

5. Down-coiler

Via a delivery roller table, including a 60 m. long strip cooling section, the strip is passed to two down-coilers. Here the strip is built up into coils and then deposited on a belt conveyor.

DEMAG AKTIENGESELLSCHAFT DUISBURG GERMANY

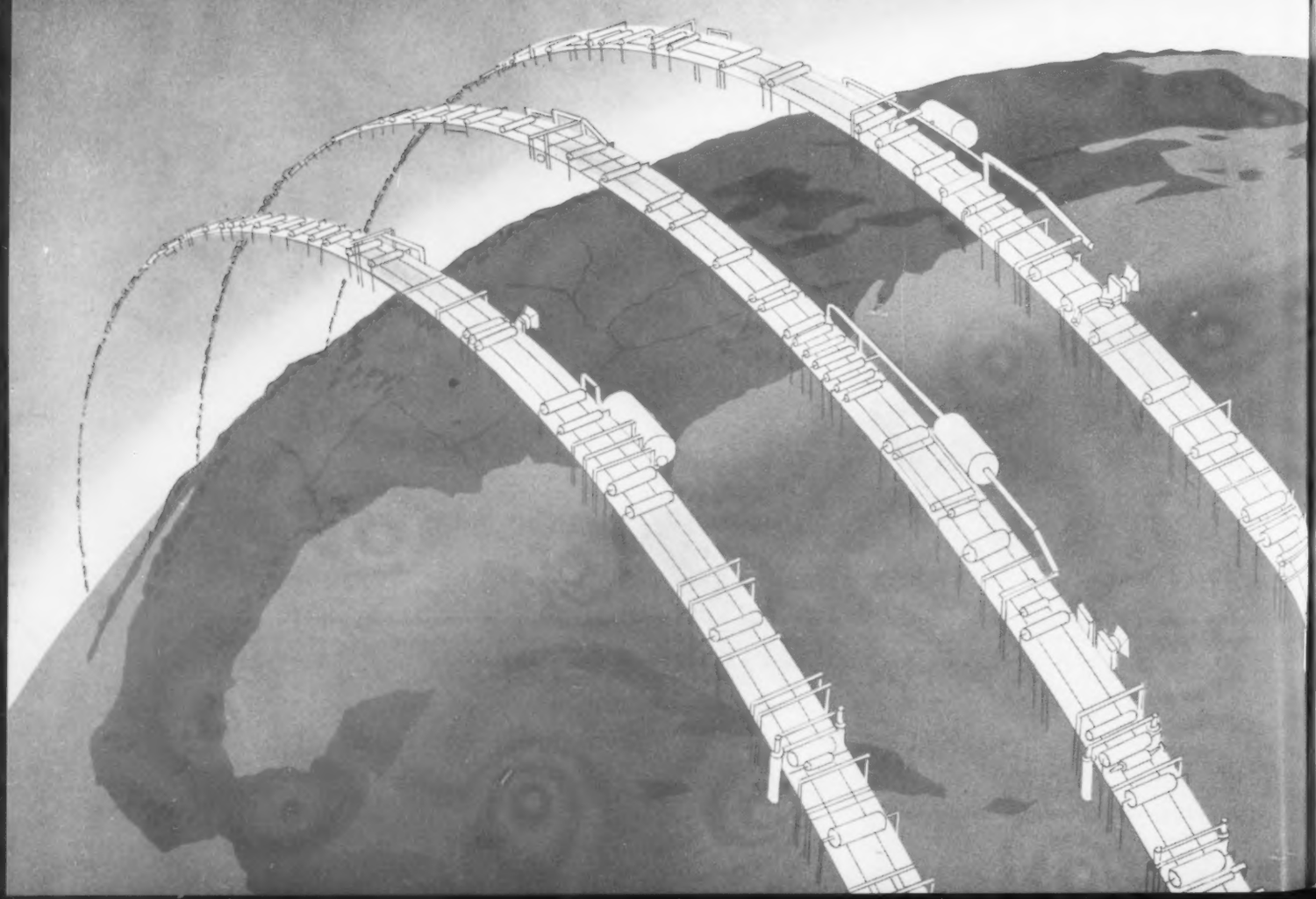
MURRAY MAKES PROGRESS

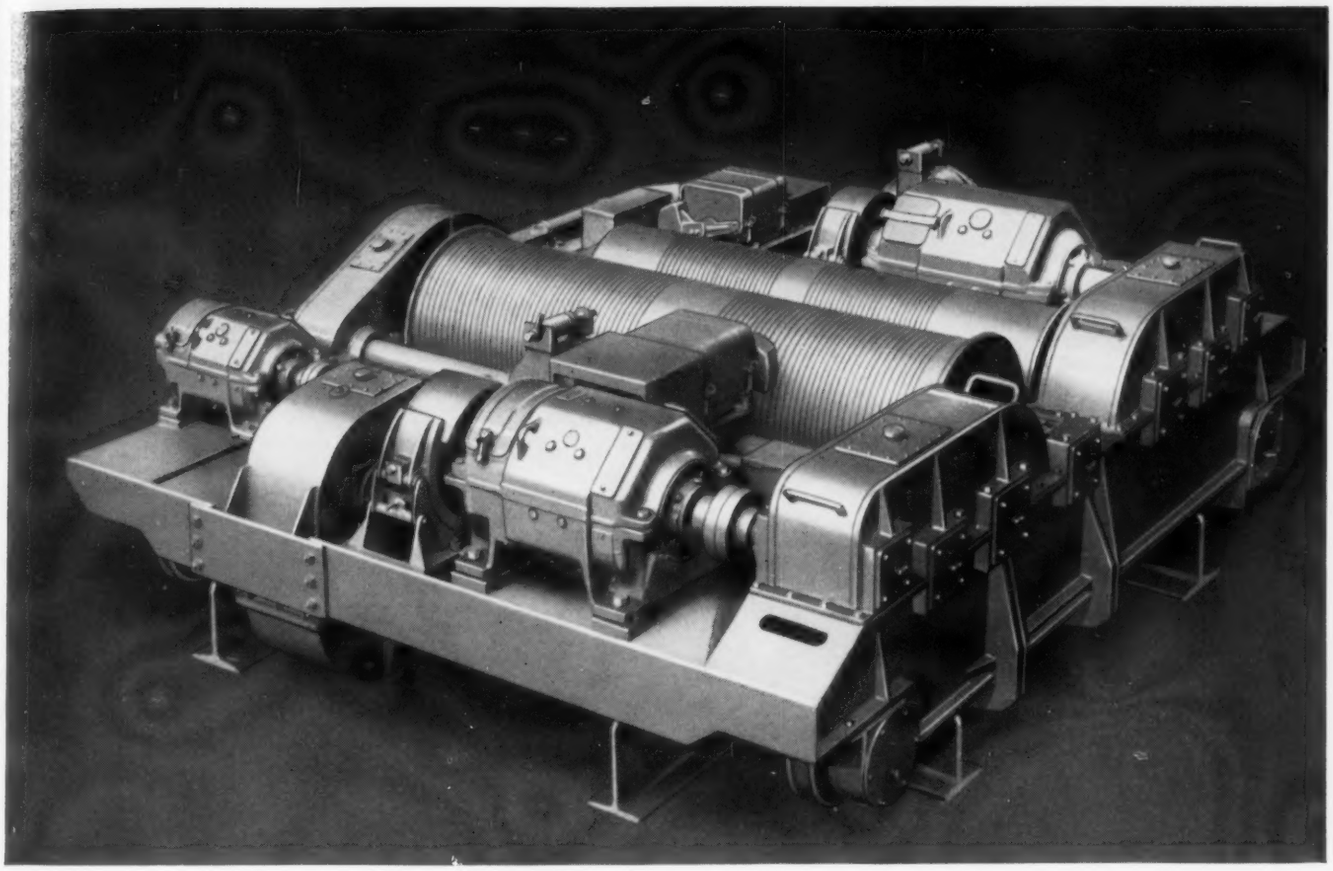
in Electrical Construction, in Steel Mills, Automobile Manufacturing Plants, and in Heavy Industry . . . .

• Capital investment equipment starts producing sooner when the Murray organization is executing your construction projects. In a diverse field of industrial activity, Murray-Men are making a reputation for completion of contracts substantially ahead of schedule. This is an important factor in planning for increased productivity. You will find it to be good business to include Murray in your plan for future expansion.

DAVID W. MURRAY COMPANY

Detroit • Toledo • Cleveland • Pittsburgh
Main Office • P. O. Box 4768 • Cleveland 26, Ohio





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Trolleys

FOR HEAVY DUTY MILL TYPE CRANES

"Simple Design is Sound Design"

We offer a complete line of trolleys built to meet the most exacting requirements. These trolleys are constructed of the finest materials available. No cast iron is used. All shafts are of highest quality alloy steel. All bearings are calculated with a proper life factor for service required as defined by the A. I. S. E. We will build a trolley to fit your special requirements as to gauge, head room, approaches and general arrangement. We also make a complete line of cranes for steel mill use. . . Your inquiries will be welcome.

VICTOR R. BROWNING & COMPANY, Inc.

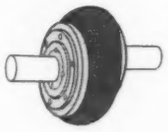
BOX 309, WILLOUGHBY (CLEVELAND), OHIO

Designers and Builders of Electric Overhead Traveling Cranes and Hoists and Electric Revolving Cranes

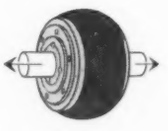
Acid Pump Drive . . . Kaiser Steel Corporation, Fontana Works

DODGE
Para•flex

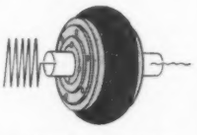
Takes
Angular Misalignment



Takes
Parallel Misalignment



Takes
End Float



Absorbs Vibration

Years of heat and acid

Tough operating conditions are taken in stride by Dodge Para-flex. These flexible cushion couplings can stand most anything. After years of exposure to acid fumes, heat and ozone on this acid pump, the tire-like flexing element of the Para-flex still does its job.

Dodge Para-flex flexible cushion couplings "swallow up" angular and parallel misalignments, end float (or any combination), absorb vibrations and cushion shock loads.

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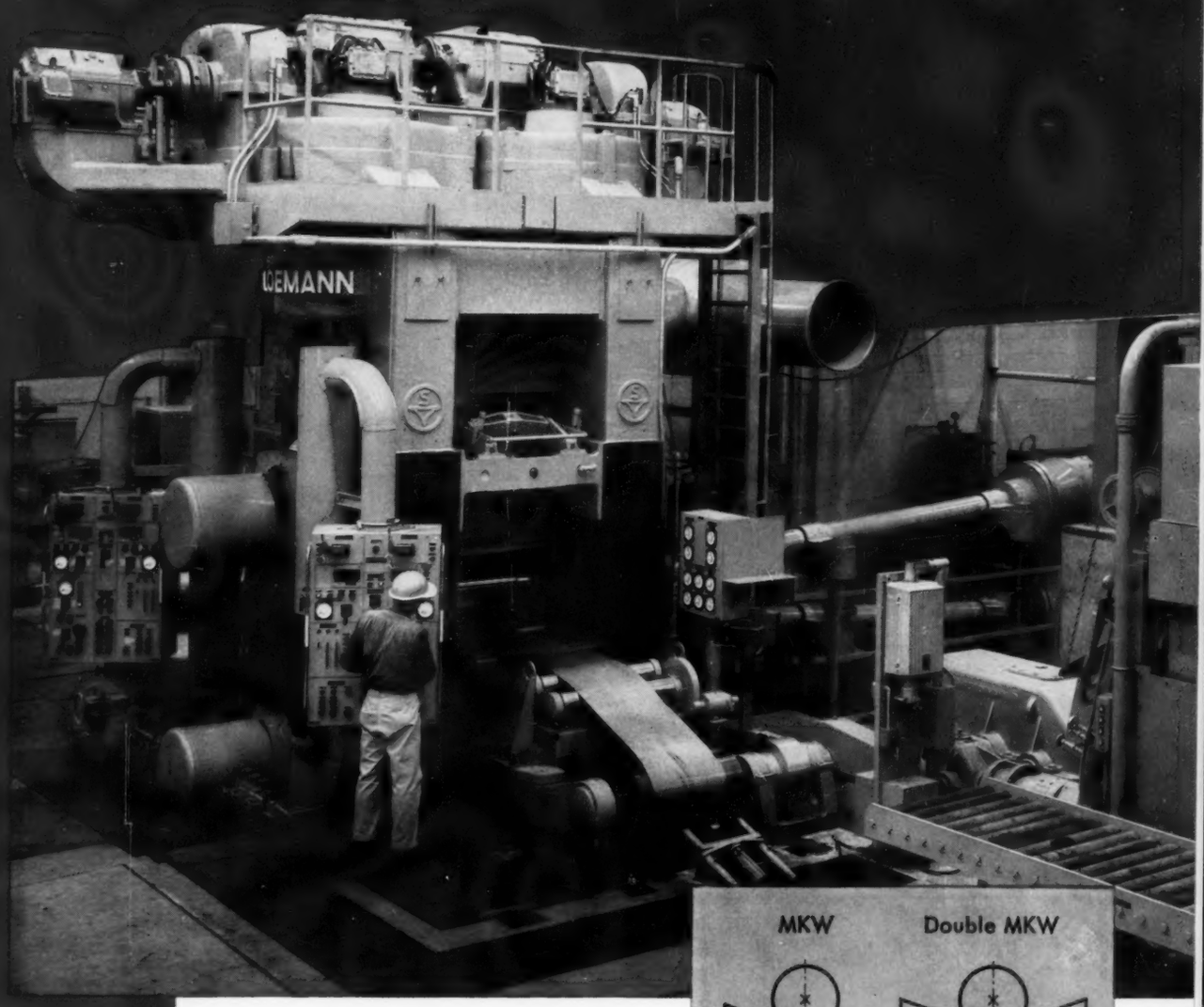

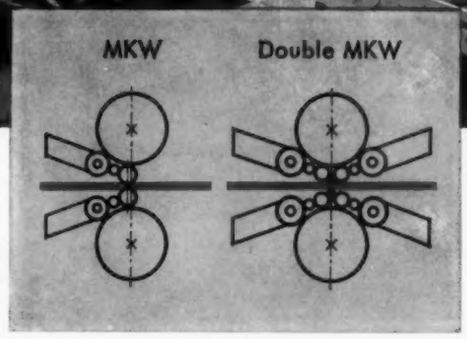

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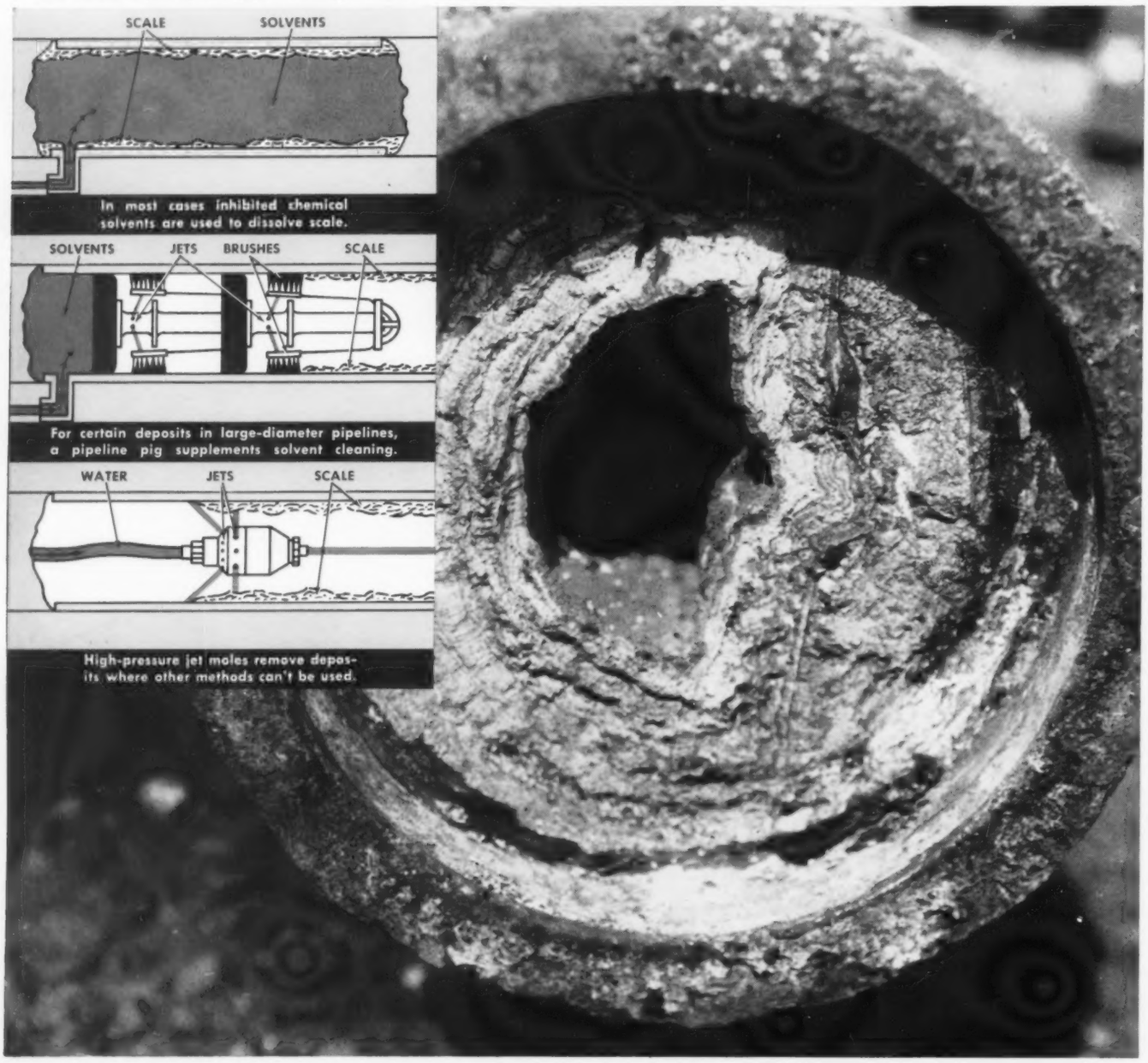

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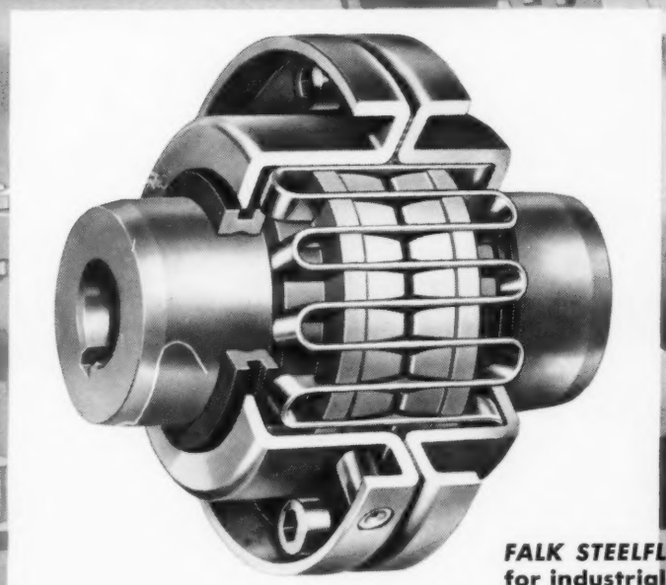

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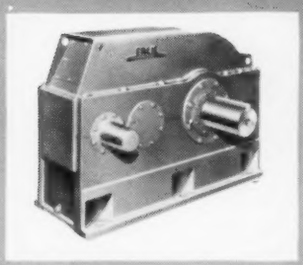

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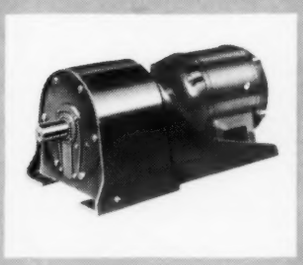

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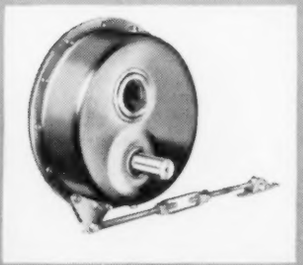

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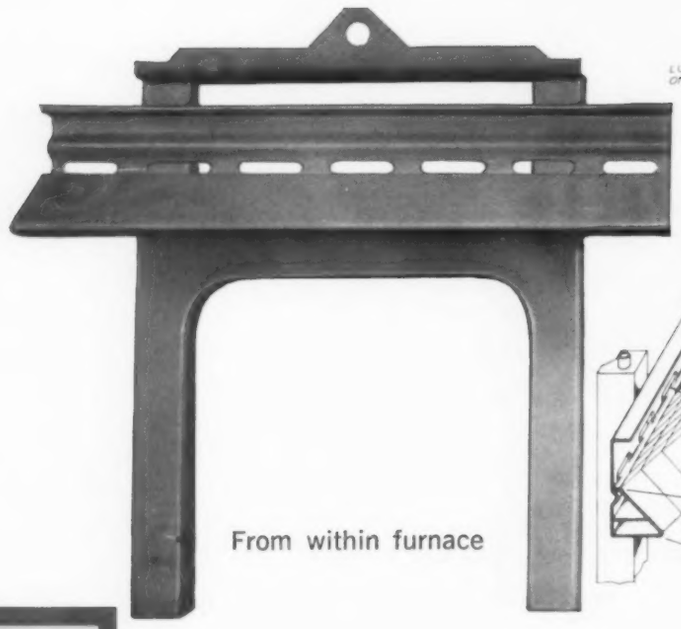

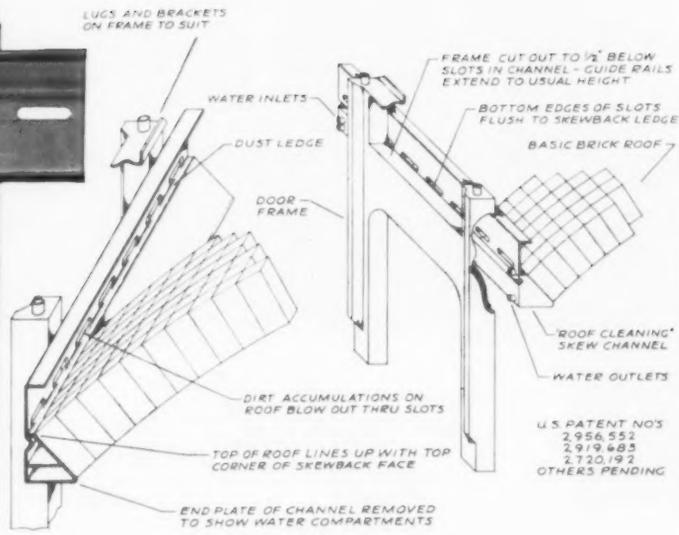
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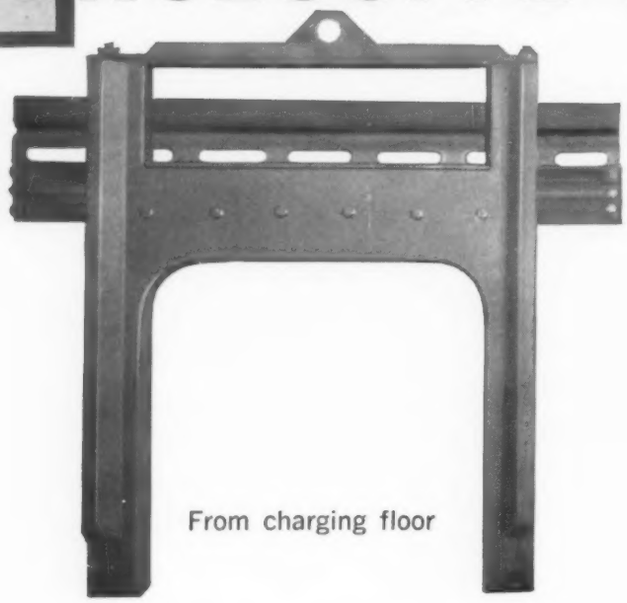

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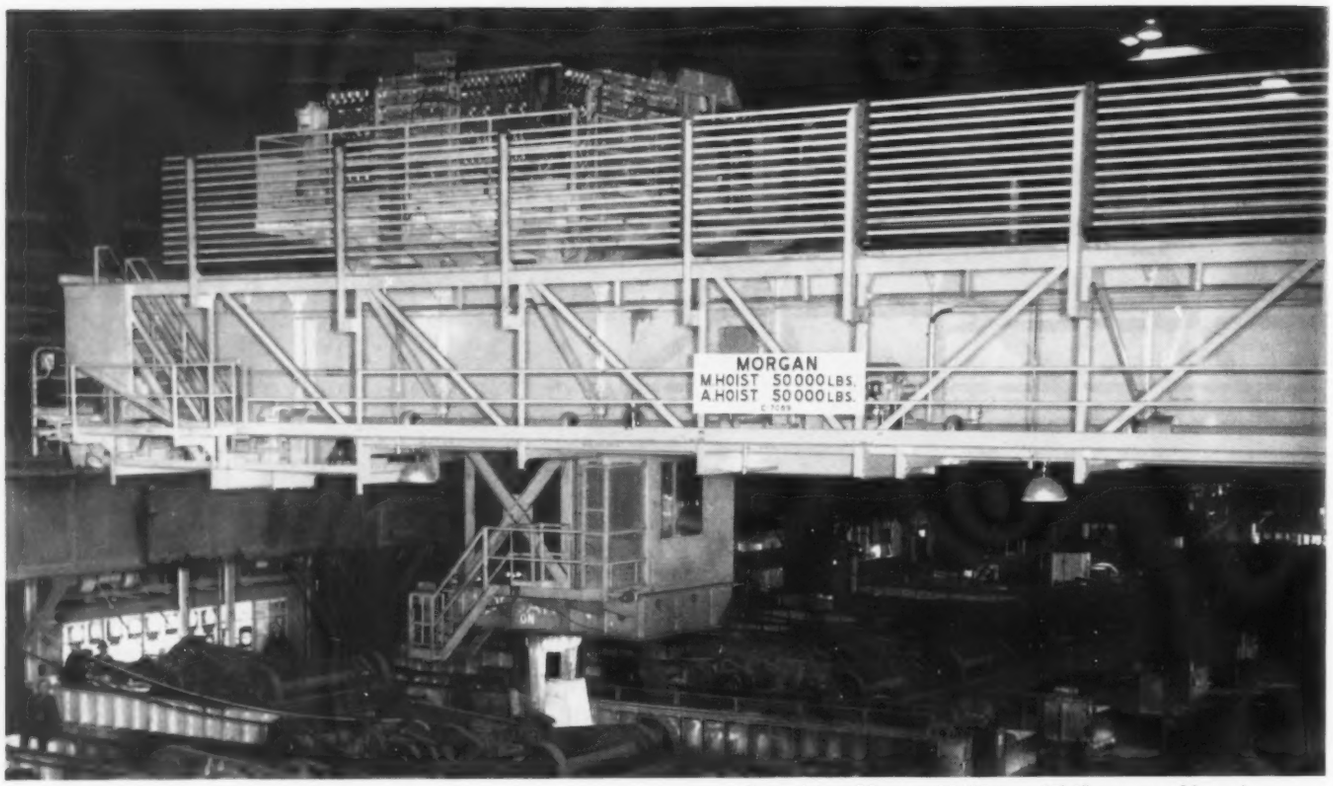

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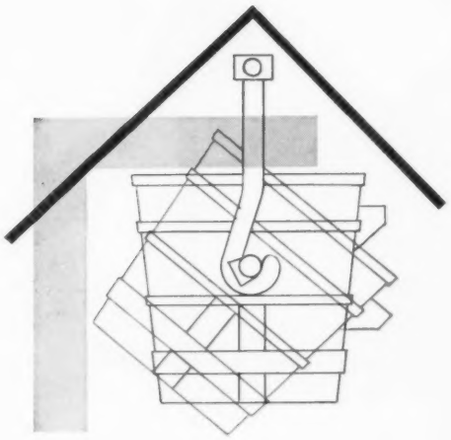

STEEL ANGLES

THE recent decision of the British to apply for membership in the common market raises some interesting questions about the increase in the effectiveness and influence of that enlarged economic community in relation to the United States.

At present, the European Economic Community consists of six nations: France, Western Germany, Italy, Netherlands, Belgium and Luxembourg. These are the inner six, while the Free Trade Association, sponsored initially by Great Britain, consists of Britain, Sweden, Norway, Denmark, Switzerland, Austria, Finland and Portugal. With Britain out of the Free Trade Association, it is most likely that several of its other members may well apply for membership in the economic community, or what is known more popularly as the common market. It seems certain that Denmark and Norway will apply, and the others will ask for the status of associate members which will give them certain tariff privileges without having complete membership.

Complete economic cooperation with the elimination of tariffs and other barriers among so many nations would provide something very close to an economic United States of Europe. Whether this would become a political entity as well as a matter of conjecture, and will not be determined for some time to come.

The effect on the United States of such a large and influential combination could be substantial. In considering the steel industry alone, we see the emergence of a large competitive force. In terms of 1960 steel production, as well as the projected capacity for 1965, the European Economic Community will be almost on a par with the United States. The figures are striking. In the United States steel output in 1960 was just short of 100,000,000 tons; in the present common market area, steel production was slightly in excess of 80,000,000 tons. If, however, the output of the United Kingdom, Austria, Denmark, Norway, Sweden and Switzerland is included in these figures, an extra 36,000,000 tons would be added to the figure bringing the total to 116,000,000 tons, which is just short of the all time record output of about 117,000,000 tons produced in the United States in 1955. These are the facts for 1960.

Looking ahead to 1965, there is little to be consoled about in regard to our competitive position. The six nations in the present European Economic Community plan expansion of steelmaking facilities so that capacity will be about 99,000,000 tons. This will be augmented by another 50,000,000 tons from Great Britain and the other countries who are prospective, full members or associates of the common market group. Thus there would be a total of 149,000,000 tons which is exactly the capacity figure the United States had in January, 1960. Further, most of this European capacity will be modern and, consequently, capable of efficient and low cost operation.

Some have speculated on the growth of the steel industry in the United States between now and 1965, but no definite figures are offered. There are two good reasons for this. First, the task in the United States is one of modernization rather than expansion. We are and should be much more concerned with replacing obsolete plant than adding new plant to the old. Second, the use of oxygen both in the new converter and existing open hearth shops could increase present output potential by a considerable tonnage. Yet, it will be another year or more before we can evaluate the contribution of oxygen to steelmaking with any degree of accuracy. It seems quite safe to say, however, that the capacity in the United States in 1965 will be greater than that of the common market.

The most significant question on this subject is not so much a comparison of capacity to produce, but rather the ability of that capacity to satisfy the market. Will we be able to look to Europe as an export market by 1965, or will the 149,000,000 tons of steel be enough to take care of the internal needs of Europe and provide a surplus for exports?

We can but conjecture on the point at this time, yet it seems that our exports of steel to Europe can only be maintained if the growth of the European Economic Community by the addition of the new members results in expanded economic activity there. This is a very strong possibility, and the United States could well participate in such an expanded market.

A further question arises, viz., if the European economy has a slack year or two in the next ten, will the steel there be shipped here at bargain prices, and how will this affect our industry? Without question there is such a possibility, and we must prepare for it. One of the best ways to do so is to pursue a program of efficiency in operations so that costs can be held down. Indeed such a program becomes increasingly necessary and can be carried out only if the steel industry in the United States can generate enough capital through depreciation charges to modernize that portion of its equipment which is now obsolete. Thus, it is necessary for our Government to consider depreciation reform in view of the coming increase in foreign competition. ▲

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Roll Wear in Finishing Trains of hot strip mills

by DR. GEORGE SACHS†
Associate Director
JAMES V. LATORRE
Research Engineer
and M. K. CHAKKO
Graduate Assistant
Metallurgical Research Laboratory
Syracuse University Research Institute
Syracuse, N. Y.

. . . . a joint AISE-RMI program was evolved to study roll spalling and it was felt that a study of roll wear which would include a significant number of measurable variables might establish some relationship between the two roll phenomena. The wear contours obtained and their relationship to mill width, strip mileage, roll tonnage, roll separating force and the as-ground roll contour are presented with a number of conclusions from which it would appear that roll separating force is the most important factor in determining roll performance . . . .

A RESEARCH program at Syracuse University, sponsored by the Joint Roll Research Committee of the Association of Iron and Steel Engineers and the Roll Manufacturer's Institute, is aimed at analyzing the problem of roll spalling and at determining its effect on roll life. In this program, the various significant rolling variables which can be observed with currently available instruments are measured. Then, these data are analyzed both in their own right as specific phenomena and in regard to their significance to the problems of spalling and roll life.

Roll wear and roll spalling are very complex phenomena and little quantitative information is available in regard to the different components of this problem.

The rolls of a mill are subjected to stresses resulting from the roll separating force, from temperature fluctuations and those retained from either casting or heat-treating. The contours of the rolls vary with different crowning practices and change during rolling because of heating and wear. All these features of the rolling process must be established to explain fully the problem of roll spalling and to minimize this threat to roll life.

One of the components of this problem, which can be rather readily isolated, is roll wear.

Although studies of roll wear were conducted by Caswell[1]* in 1934, little factual information was available until very recently. The first investigations dealt primarily with the sheet contour and its changes during a rolling cycle between grinding of the rolls.[1,2] With the exception of a few observations on grooved rolls,[3] Palamarchuk's data[4] in 1957 were the first published measurements of actual wear. These data were limited to the backup rolls of a 6-stand, 67-in. hot strip finishing mill train designated as stands 5 to 10. Practically no wear was reported in stands 5 to 8, and in stands 9 and 10 wear was reported only if hard work rolls were used.

Further data on roll wear were obtained by Peck[5] on

† Deceased.

* Numbers refer to Bibliography at end of article.

TABLE I
Test Project Mill Characteristics

Mill data	Roll data	Stand no.	Motor hp	Gear ratio	Average strip exit speed, fpm	Average reduction, per cent
A 44-in. semi-continuous hot strip mill with cooling water at 200 psig	A 22½ x 44-in. work roll with roller bearings and a 46 x 43-in. backup roll with 0.030 x 6-in. edge relief and oil-film type bearings	1	3000	6.333	360	49
		2	1000	3.545	540	33
		3	3000	Direct	830	35
		4	3000	Direct	1080	23
		5	3000	Direct	1540	29
		6	3000	Direct	1800	14
A 56-in. semi-continuous hot strip mill with cooling water at 120 psig	A 22½ x 56-in. work roll with roller bearings and a 45 x 54-in. backup roll with ¼ x 3-in. edge relief and oil-film type bearings	1	3500	40/180	350	49
		2	3500	35/90	595	41
		3	3500	45/80	840	29
		4	3500	52/73	1090	24
		5	3500	Direct	1330	18
		6	3000	Direct	1400	3.7
A 96-in. continuous hot strip mill with cooling water at 100 psig	A 27 x 96-in. work roll with roller bearings and a 53 x 90-in. backup roll (no edge relief) with oil-film type bearings	1	4500	3.783	335	45 (Estimated)
		2	4500	2.261	535	37
		3	4500	1.551	770	30
		4	4500	1.193	1100	32
		5	4500	Direct	1400	20
		6	3000	1.193	1540	10
A 56-in. cold strip mill with cold water and coolant on stand 1 and warm oil emulsion lubricant on stands 2, 3, 4 and 5	A 21 x 56-in. work roll with roller bearings and a 53 x 55-in. backup roll with oil-film type bearings	1	1500	Direct	455	54
		2	2500	Direct	800	43
		3	2500	Direct	1450	45
		4	2500	Direct	2040	29
		5	3000	Direct	2880	28
		Tension reel	800			

two hot finishing trains of steel strip mills during an earlier project sponsored by the Joint Roll Research Committee.

The only investigation which established the effects of a number of variables on roll wear has been performed by Sibakin, Ride and Sherwood[6] on a 6-stand, 56-in. hot strip finishing train of the Steel Co. of Canada. The work rolls of this mill were generally double-poured cast iron, although cast-steel work rolls were occasionally used in the first two stands. The backup rolls were usually cast steel. Occasionally backup rolls with a forged-steel sleeve, shrunk on turned down cast-steel rolls, were used. Very little wear was reported on either the work rolls or the backup rolls of stands 1 and 2. Maximum wear was reported for stands 4 and 5. The wear of the work rolls progressed linearly with the rolled tonnage. Further results of this work will be discussed in connection with the present results.

The study of roll wear presented here is a continuation of these previous investigations and part of it has been performed in close cooperation with the Steel Co. of Canada, as parts of a more general program. Several publications will describe the scope and results of these projects and this article is one of this series.[14,15,16]

EQUIPMENT AND PROCEDURE

The program of this project included roll contour measurements on three hot and one cold mill. The work on the hot mills related to three 6-stand finishing trains of different width: a 44-inch "narrow" mill; a 56-in. "intermediate" mill; and a 96-in. "wide" mill. The cold mill was a 56-in., 5-stand tandem mill. Some of the characteristics of these mills are given in Table I.

Work roll contours on the narrow and on the wide mills were obtained during a period of 12 turns each. Work roll contours on the intermediate hot mill and the cold mill were taken during a period of eight turns. Backup roll contours were obtained on these mills during a period of 60 turns covering three backup roll changes. A turn is defined as an 8-hr work shift.

For the contour measurements a Gilbertson-Thomas roll camber recorder (Figure 1) was available. It was modified to improve its positioning on the rolls and to facilitate handling. The original travel length of the recorder was reduced from 60 to 56 in. to allow measurements of the 56-in. backup rolls, in the mill. In order to obtain the wear patterns of the 96-in. mill rolls two contours were taken, each covering about 48 in., and these were assembled to obtain the entire contour. The roll contour record consists of a card, see Figure 2. This record was complemented by micrometer measurements of the diameter at the center and at equal distances from the center, under the rests of the recorder. These reference points were about six in. from the edges of the cylindrical roll length and, as far as the work rolls are concerned, usually outside of the wear pattern. The wear patterns reported below have been constructed from these measurements.

Figure 1 — Measurement with the roll camber recorder was complemented by three micrometer measurements.

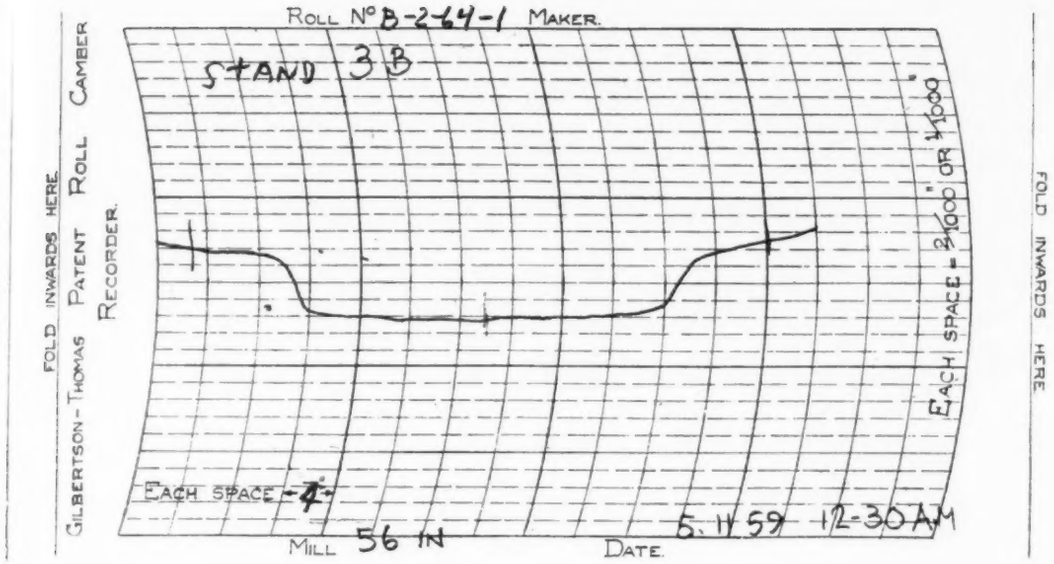


Figure 2 — The measured roll contour is etched on a wax coated card.

The results of the study are reported in the form of graphs which are self-explanatory and which contain the data pertinent to the tests. The ordinate of the graphs is the difference between the initial one half roll diameter and the actual one half diameter along the roll surface. In each graph the initial roll contour is indicated by a dashed line and the amount of wear by shading.

The contours of the work rolls are based on records taken at least four hr after removal of the rolls. No correction was required, if this time was more than eight hr, as the temperature was then generally the same at all surface locations. Otherwise, the temperature difference between center and edge, which amounted to about 25 F maximum, required a slight radial shift of the wear pattern by not more than 0.0015 in. in the center in order to compensate for expansion. The contours of the backup rolls were measured within several hr after shutdown with their surface temperatures always being quite uniform.

The wear of rolls, in general, results from the sliding movements of the two surfaces in contact under pressure. The pressure distribution is related to the rolling schedule of the mill. In order to evaluate possible relations between the work load and the wear, the rolling performed during the periods considered has been also represented graphically in the form of "cumulative ton-width distribution" graphs. These graphs are obtained by determining the tonnage for different strip width intervals and adding these from the maximum strip width to the minimum toward the roll center. They represent, therefore, the total or cumulative tonnage in contact with the respective longitudinal increment of the roll surface. Although these graphs cannot be considered to represent an ultimate evaluation of the work load, it is easily obtained and this appears suitable as a first step of a more complete evaluation.

In order to compare roll wear for different stands, it should be related to some standard unit. For the purpose of the present discussion it appeared desirable to first relate the wear to a unit tonnage for one in. of average strip width. The unit tonnages selected were 25 tons per in. of strip width for work rolls and 1000 tons per in. of strip width for backup rolls. These units represent, approximately, the minimum work cycles for these rolls.

The relation can be shown by a formula:

$$w_1 = \frac{btW}{T}$$

where w_1 = radial wear, in. per unit tonnage; W = total radial wear, in. per roll cycle; T = total tonnage per roll cycle; b = average strip width, in.; and t = unit tons per in. of strip width (25 tons for work rolls and 1000 tons for backup rolls).

One step further in the analysis is relating the wear to the mileage of strip rolled and, therefore, in contact with the roll surface at the exit from the stand. This quantity could be determined only approximately from measured roll surface speeds, where available, assuming that exit strip speeds are identical to the respective roll surface speeds, or, alternatively, from measured strip speeds. Also assuming reasonable average values of entry thickness and reduction in the first stand (from available typical drafting procedures) average values of mileage can then be calculated from the values of tonnage per in. of average strip width. This relation can also be shown by a formula:

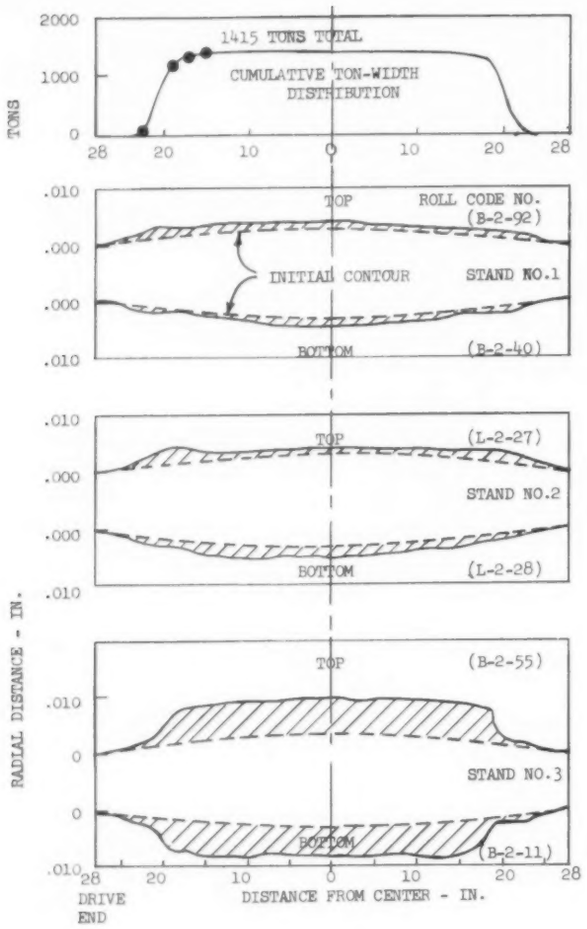
$$w_2 = \frac{S_1}{S_n} w_1$$

where w_2 = radial wear per in. per unit mileage (45,000 ft for work rolls and 1,800,000 ft for backup rolls); w_1 = radial wear, in. per unit tonnage; S_1 = exit speed, stand 1; and S_n = exit speed, stands 2 through 6.

The unit mileage corresponds with the unit tonnage per in. of strip width converted into feet of strip, exiting from stand 1, assuming an exit gage of 0.325 in.

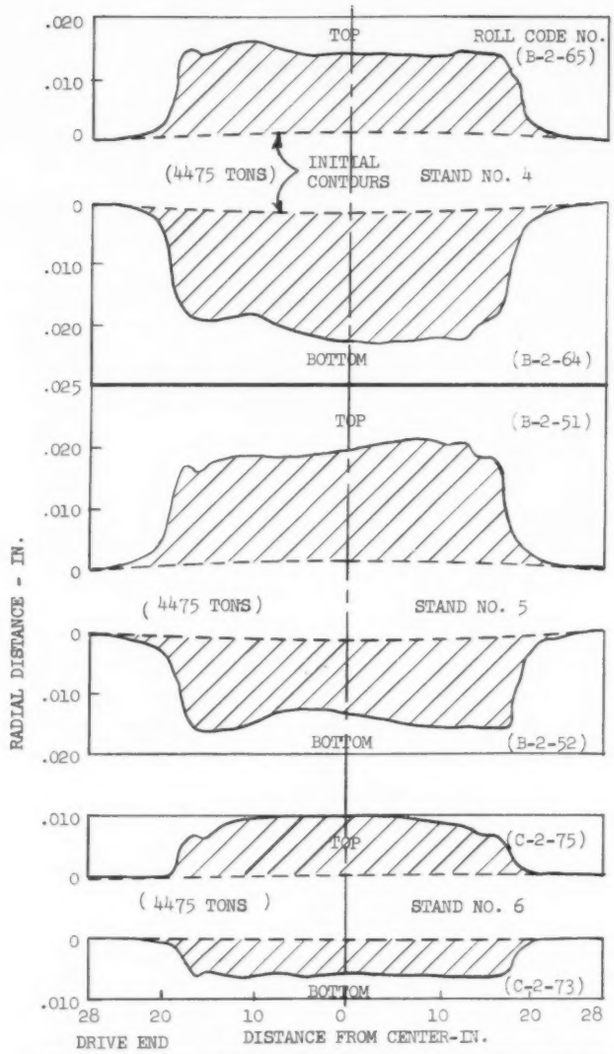
WORK ROLLS WEAR IN HOT FINISHING MILLS

For each of the three hot mill trains investigated, a number of wear patterns for the work rolls are illustrated by the graphs made. First, one or two groups of measurements are presented for the same or overlapping cycles, but usually only for three to five stands of



	STAND NO.1	STAND NO.2	STAND NO.3
ROLL MATERIAL	D.P. IRON	D.P. IRON	D.P. IRON
HARDNESS - SHORE	79/81	75/77	79/80
NOMINAL/TEST DIAM.	22.8/20.9	22.8/22.5	22.8/21.8
CROWN-DIAM.	.007 CONCAVE	.007 CONCAVE	.007 CONCAVE

Figure 3 — Roll wear patterns are for stands 1, 2 and 3 of the 56-in. mill.



	STAND NO.4	STAND NO.5	STAND NO.6
ROLL MATERIAL	D.P. IRON	D.P. IRON	D.P. IRON
HARDNESS-SHORE	77/88	80/82	75/76
NOMINAL/TEST DIAM.	22.8/21.5	22.8/22.1	22.7/22.7
CROWN - DIAM.	.003 CONCAVE	.003 CONCAVE	0

Figure 4 — The wear pattern of the rolls from stands 4 to 6 appear box shaped.

the mill. In one instance, measurements for all six stands could be obtained. In addition, a number of individual wear patterns are given which illustrate observed extremes.

The most frequently observed wear pattern is a box-shaped depression with sloping walls. It is predominant for stands 4 to 6, and also frequently encountered in stand 3, while the wear pattern of stands 1 and 2 has been found to vary greatly from mill to mill and also from one cycle to another.

Furthermore, the box-like pattern is an image of the cumulative ton-width distribution. Therefore, it is attributed to the progressive abrasive effect of the rolled material on the work roll surface.

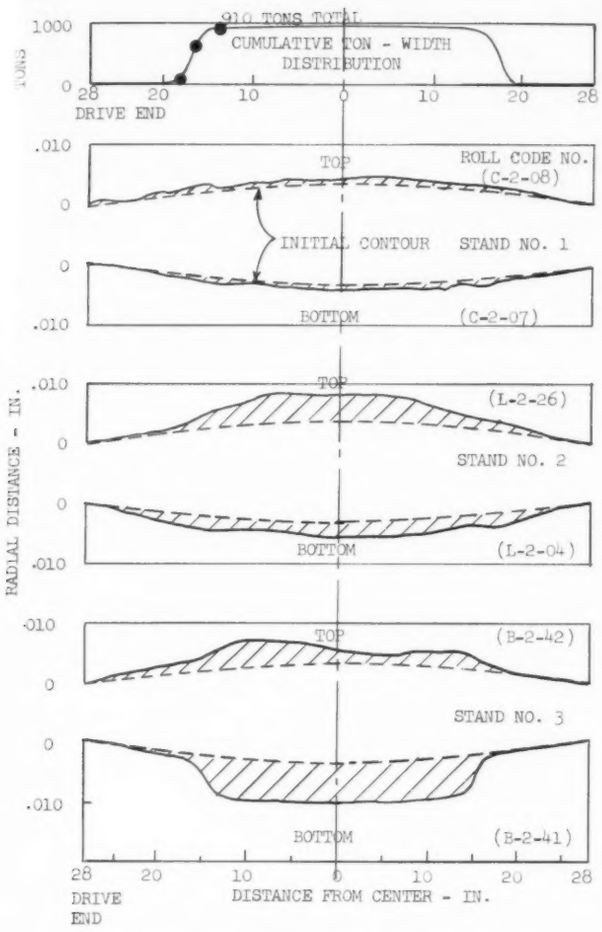
This also applies to the stepped wear patterns occasionally observed. These are explained by a rolling schedule that includes a great amount of narrow strip, such as skelp.

Very irregular wear patterns were frequently encountered in stands 1 and 2. These will be discussed further.

It may be noted that in addition to the major wear resulting from rolled strip, a comparatively small amount of wear is encountered outside the work roll length which is in contact with the rolled material. From the later discussed wear patterns of the backup rolls, it appears established that the backup rolls remain in nearly full contact with the work roll during most of the rolling cycle. It must be assumed, therefore, that this contact not only explains the wear of the backup rolls but also a small part of the wear of the work rolls.

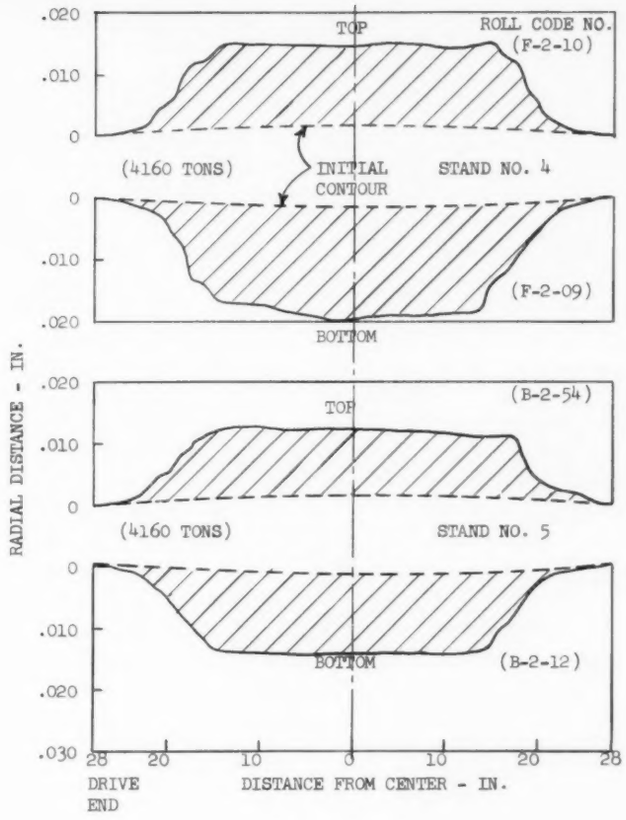
Because of the short work roll cycle, this wear component is difficult to determine. Although the wear of the work roll seems less, it approaches the same order of magnitude as the wear of the backup rolls. The work roll has the higher hardness, 75 to 80 shore, compared with 40 to 45 shore for the backup roll. It should be expected that, for a given mileage, work roll wear may be greater than the backup roll wear due to the difference in roll diameters and the resulting increased contact time for the work roll.

The wear of the bottom roll frequently differs in magnitude from that of the top roll, although this



	STAND NO.1	STAND NO.2	STAND NO.3
ROLL MATERIAL	D.P. IRON	D.P.IRON	D.P. IRON
HARDNESS SHORE	77/80	76/80	82/85
NOMINAL DIAM.	22.8	22.8	22.8
TEST DIAM.	20.9	22.3	21.9
CROWN - DIAM.	.007 CONCAVE	.007 CONCAVE	.007 CONCAVE

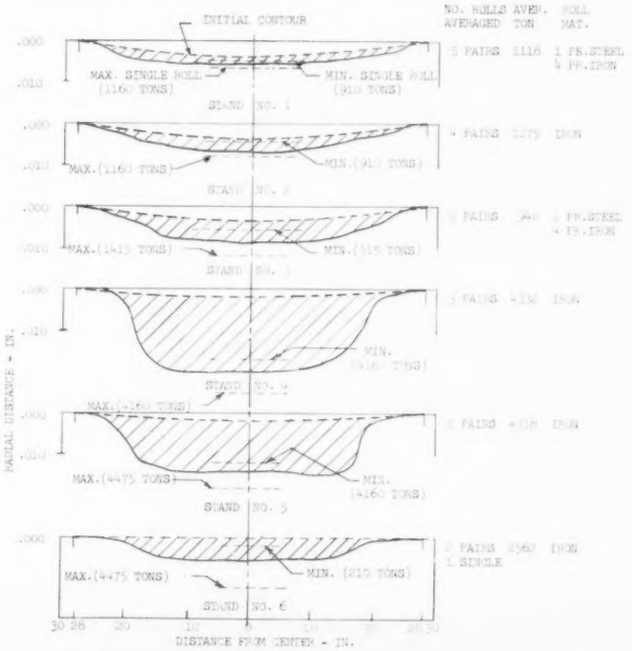
Figure 5 — Additional roll wear contours of stands 1 to 3 of the 56-in. mill are illustrated.



	STAND NO. 4	STAND NO.5
ROLL MATERIAL	D.P. IRON	D.P. IRON
HARDNESS - SHORE	77/80	80/82
NOMINAL DIAM.	22.8	22.8
TEST DIAM.	21.6	22.0
CROWN - DIAM.	.003 CONCAVE	.003 CONCAVE

Figure 6 — Additional roll wear contours of stands 4 and 5 of the 56-in. mill are illustrated.

Figure 7 — Rolls from stand 4 of the 56-in. mill had the maximum wear contours.



difference is generally small and varies for the individual mills. The narrow mill shows more wear on the bottom roll of 11 pairs, more on the top rolls of three pairs and equal wear on two pairs. The wide mill shows more wear on the top rolls of five pairs, more wear on the bottom rolls of two pairs and equal wear on three pairs. No definite difference of this nature was found to occur in the intermediate mill.

In all three mills the maximum wear in the center of the work rolls of stand 1 is found to be considerably less than in stands 2 and 3. In regard to the other stands, the various mills studied exhibit different relations.

All three mills used either cast-iron (75 to 80 shore) or cast-steel (45 to 50 shore) fork rolls in stands 1, 2 and 3. No definite difference in wear for the two materials can be established from the rather limited data in this respect, although the magnitude of wear of the steel rolls was found to be near the lower limit of the scattering range for the narrow mill, but near the upper limit for the intermediate mill. Therefore, all rolls were included in any of the averages reported below.

The 56-in. mill—More complete information has been obtained for the 56-in. mill than for the two other

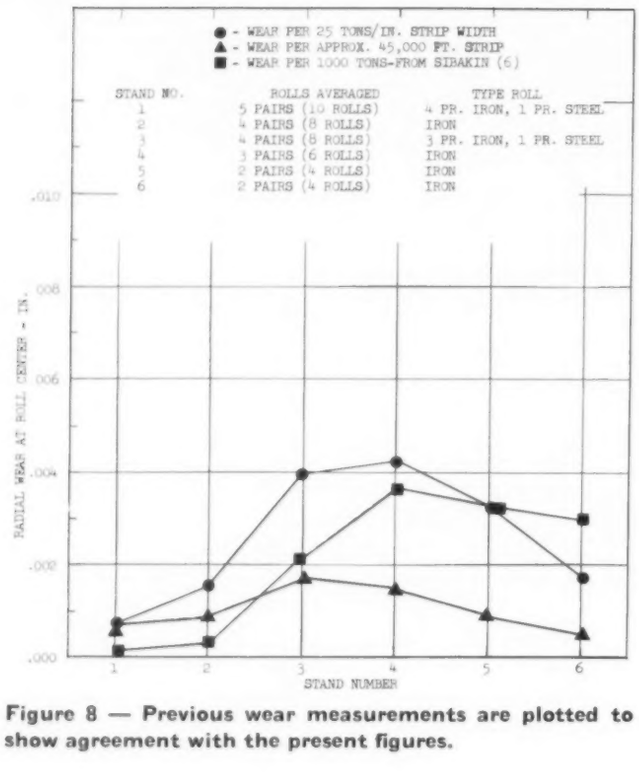

● - WEAR PER 25 TONS/IN. STRIP WIDTH
▲ - WEAR PER APPROX. 45,000 FT. STRIP
■ - WEAR PER 1000 TONS-FROM SIBAKIN (6)
STAND NO. ROLLS AVERAGED TYPE ROLL
1 5 PAIRS (10 ROLLS) 4 PR. IRON, 1 PR. STEEL
2 4 PAIRS (8 ROLLS) IRON
3 4 PAIRS (8 ROLLS) 3 PR. IRON, 1 PR. STEEL
4 3 PAIRS (6 ROLLS) IRON
5 2 PAIRS (4 ROLLS) IRON
6 2 PAIRS (4 ROLLS) IRON
RADIAL WEAR AT ROLL CENTER - IN.
.010
.008
.006
.004
.002
.000
1 2 3 4 5 6
STAND NUMBER

Figure 8 — Previous wear measurements are plotted to show agreement with the present figures.

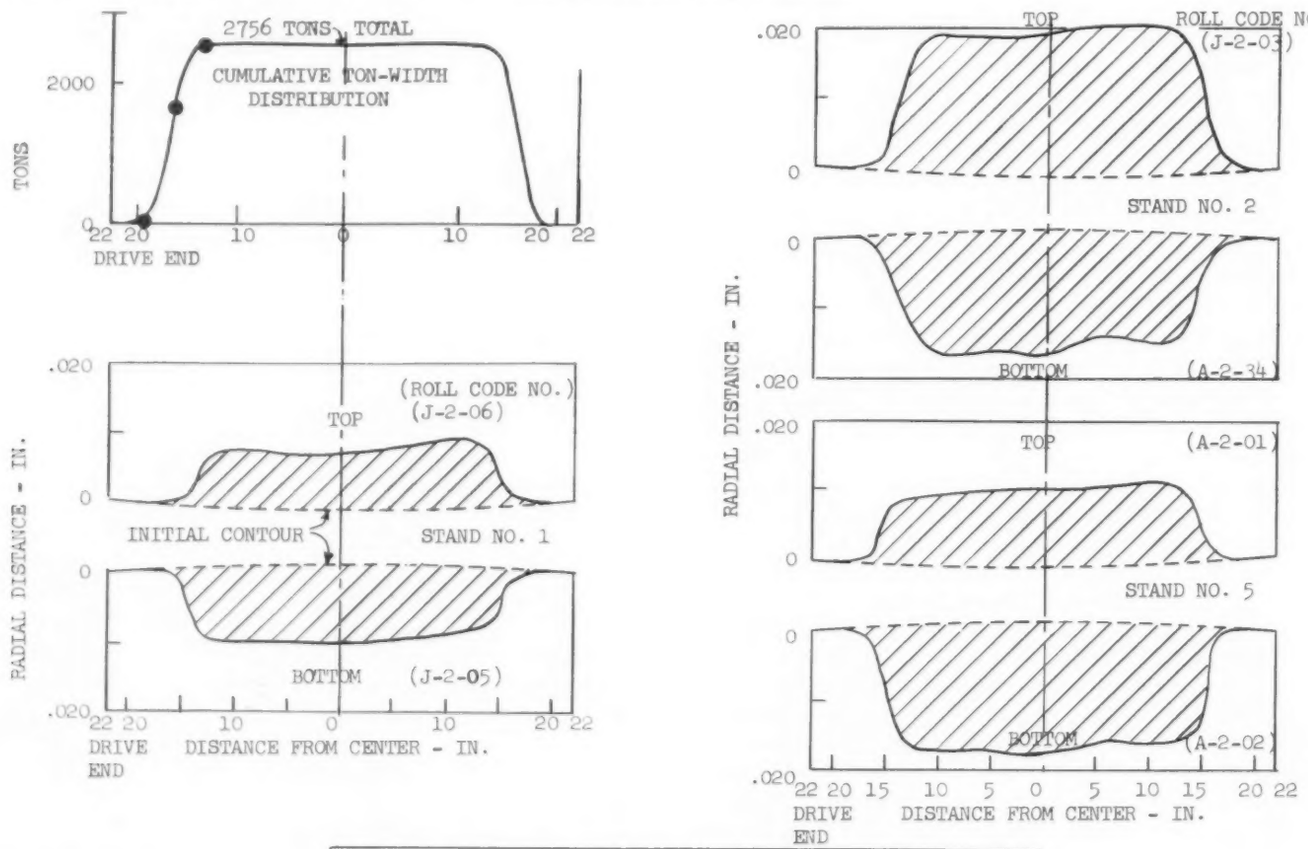
mills. For simultaneous rolling in this mill one complete set of data (Figures 3 and 4) and another set without stand 6 (Figures 5 and 6) are available. In addition, measurements were taken on a considerable number of other rolls at different times, particularly of the first three stands. The average wear contours obtained from these readings are represented in Figure 7.

The wear pattern for the first two stands of this mill is not clearly established, because of its low magnitude. It appears to be lens shaped rather than box shaped, as reported previously by Sibakin, Ride and Sherwood.[6] The wear contours of the rolls in stands 3 to 6 follow the box-shaped pattern, although irregularities are frequently noted.

The amount of wear at the roll center for a given tonnage, is, according to Figure 8, rather small for stands 1 and 2 and nearly equal for stands 3, 4 and 5. It is considerably less for stand 6. The results of previous measurements of wear on the same mill, reported by Sibakin, Ride and Sherwood,[6] are added to Figure 8. They are roughly in agreement with those from the present investigation, considering the wide variation in wear which is generally observed under apparently identical rolling conditions.

The amount of roll wear for a given mileage shows a maximum for stands 3 and 4.

Figure 9 — Stands 1, 2 and 5 of the 44-in. mill had box-shaped wear contours.



STAND NO.	1	2	5
ROLL MATERIAL	D.P. IRON	D.P. IRON	D.P. IRON
HARDNESS - SHORE	72	68	78
ORIGINAL /TEST DIAM.	22.623/ 21.206	22.630/ 21.270	22.635/ 22.566
CROWN - DIAM.	.002 CONVEX	.002 CONVEX	.002 CONVEX

The 44-in. mill—Two partial sets of data for simultaneous rolling in this mill are available. Figure 9 illustrates the wear of stands 1, 2 and 5 for one such rolling, and Figure 10, the wear of stands 2, 3 and 5 for another. Additional wear patterns for all six stands are assembled in Figures 11 and 12. The wear patterns for all stands of this mill are predominantly box shaped, although those for stand 1, and to some extent also for stand 2, tend to assume irregular contours. The presence of the box-shaped pattern in the first two stands is different from the behavior of the 56-in. mill in Figure 3, and this cannot be explained at present.

The amount of wear at the roll center for a given tonnage is, according to Figure 13, greatest in stand 2, nearly equal in stands 3, 4 and 5 and considerably less in stands 1 and 6 than in other stands.

The amount of roll wear for a given mileage is also greatest in stand 2 and then decreases progressively to a rather low value in stand 6.

The 96-in. mill—Only a limited amount of data is available for this mill, relating to stands 2, 3 and 5. Figures 14 and 15 represent two sets of simultaneous readings for stands 2 and 3; Figures 16 and 17, two contour measurements for stand 5; and Figures 18 and 19, four additional contours for stands 2 and 3.

Although the box-like pattern is observed in all the reported stands of this mill, it is very irregular for stand 2.

The amount of wear at the roll center for a given tonnage is, according to Figure 20, nearly equal for stands 2 and 3 and much higher than for stand 5.

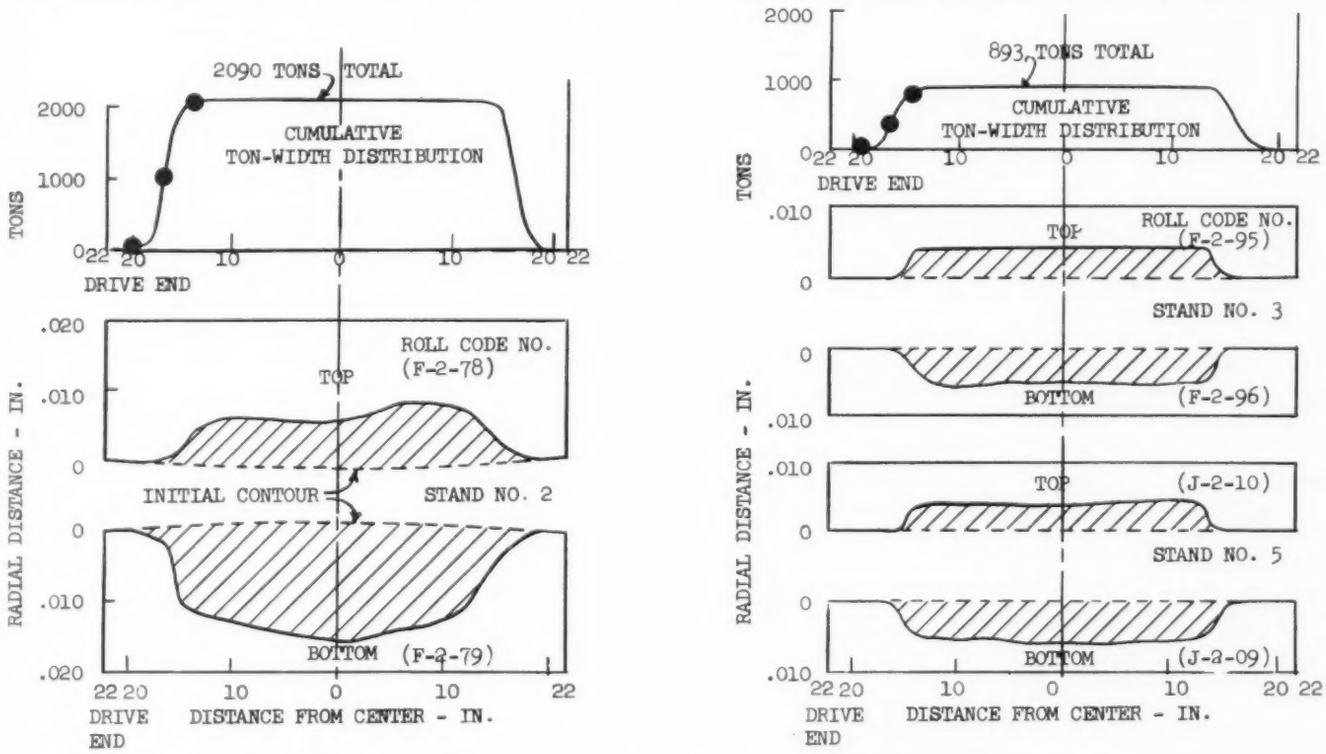
The amount of roll wear for a given mileage is found to decrease from stand 2 to stand 3 and stand 5.

Irregular wear pattern—Sharp depressions in the wear patterns of the work rolls were observed in stand 1 of the narrow mill, see Figure 11. This condition was also reported by Sibakin, Ride and Sherwood[6] in their study of the effects of various crowning practices. Their study led to a virtual elimination of these depressions by the selection of the proper roll crowning practice. It is possible that these depressions may result from a high roll surface temperature gradient near the edge of the strip, from high pressures resulting from colder strip edges or heavy edges of the entering bar—from transverse curvature of the entering bar or from strip influenced by the difference in effective crown of the top and bottom work rolls. The above conditions have greater significance if the schedule consists of rolling predominantly one strip width.

The physical reasons for the depressions and irregularities may be the development of fire cracks, associated with banding, in the first stands of the finishing train, see Figure 21.

The irregular pattern in Figure 22 may also be explained, according to Figure 23, by banding, which probably originated from thermal effects.

Figure 10 — Additional roll wear contours of stands 2, 3 and 5 of the 44-in. mill show the familiar box-shaped pattern.



	STAND NO.2	STAND NO.3	STAND NO.5
ROLL MATERIAL	CAST STEEL	D.P. IRON	D.P. IRON
HARDNESS - SHORE	48	78/80	70/71
ORIGINAL/TEST-DIAM.	22.500/ 22.441	22.614/ 22.445	22.631/ 21.638
CROWN DIAM.	.002 CONVEX	NIL.	NIL.

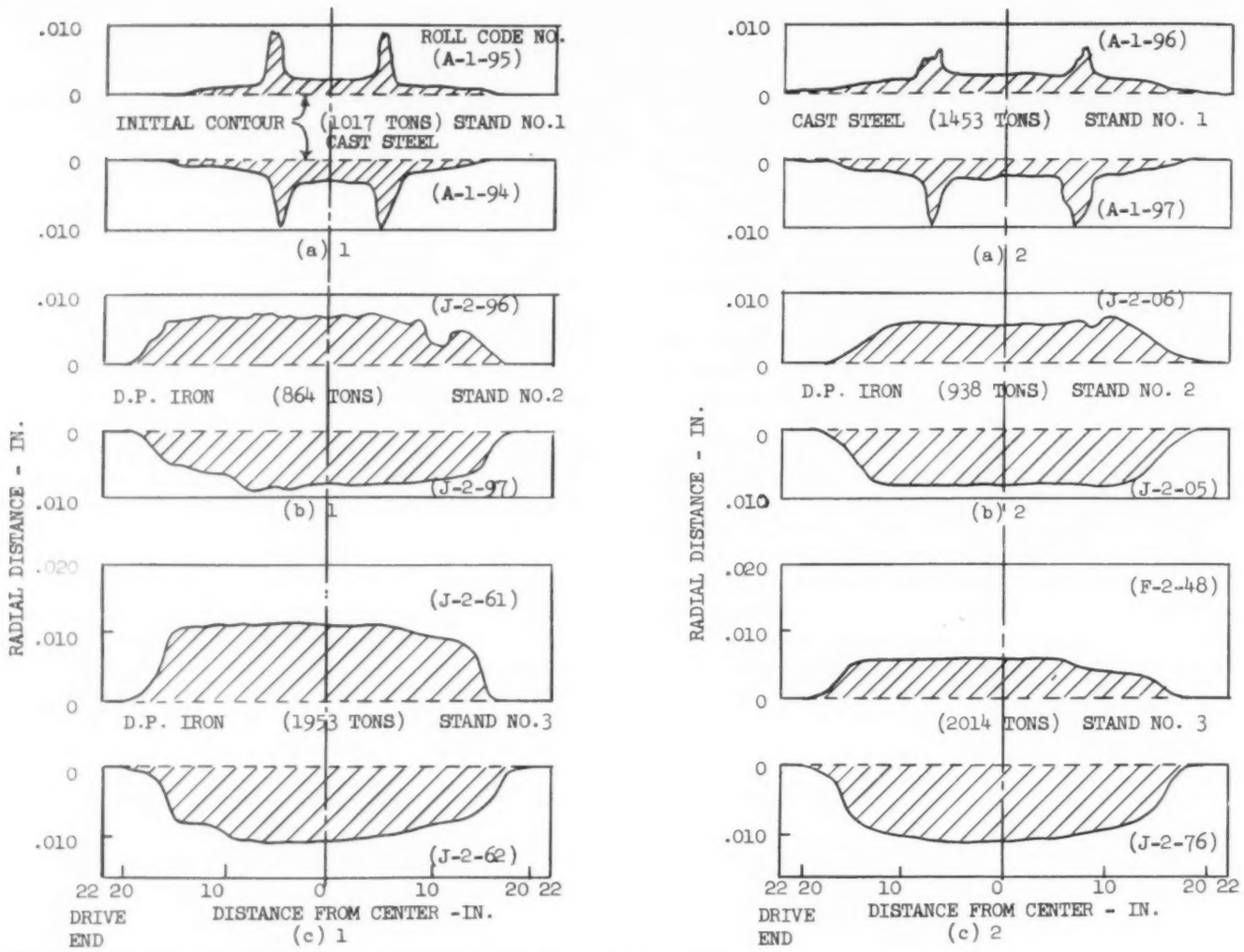


Figure 11 — The roll wear contours of stand 1 show an unusual pattern.

BACKUP ROLL WEAR PATTERNS

For two of the mill trains investigated, the narrow mill and the wide mill, only a very limited number of wear patterns for backup rolls were obtained: one wear pattern each for either both or one of the rolls of four stands. However, for the intermediate mill a considerable number of backup rolls were studied, covering each of the six stands.

It can be clearly seen from the graphs that all wear patterns for the backup rolls are characterized by substantial wear along their entire length, in contrast to previous observations of Palamarchuk.[4] This is explained by the fact that the hot finishing trains studied were generally equipped with hard work rolls and soft backup rolls, which were shorter than the work rolls. Contact between these two, during the entire cycle of the backup rolls or a substantial part of it, appears to exist over the entire length of the backup rolls.

The wear along the backup roll length is usually greater in the center. The depth of this cavity appears to vary considerably for the different trains and for the different stands of any one train. Wherever wear patterns were available for stands 1 and 2 they always indicated nearly uniform wear along the roll length, while those of other stands varied with the mill. Generally, the wear near the necks was more than one half of the wear at the center.

The amount of wear for a given tonnage and a given mileage has been determined for the backup rolls in the same manner as previously discussed for the work rolls.

The 56-in. mill—For simultaneous rolling in this mill, a complete set of data, covering only the wear patterns of the top roll, is presented in Figure 24. This graph also illustrates the progressive wear after 9½ turns (average of nine and ten turns) 16 turns and 19 turns. No tonnage data were available for this cycle. A few additional wear patterns and ton-width distributions for stands 2 and 5 are given in Figure 25.

Figure 26 assembles five wear patterns, for top and bottom rolls, for stands 3 and 4 to illustrate the variations encountered. From all the wear patterns recorded, two to three for each roll of each stand, an average roll pattern has been constructed and it is presented in Figure 27. Dashed lines in these graphs indicate the maximum variations in the roll wear at the center.

The relationship between the wear pattern and cumulative ton-width distribution is not as conclusive for the backup rolls as for the work rolls. In all stands a considerable amount of wear occurs over the entire length of the backup rolls. In the first two stands the amount of wear is also nearly constant for the entire

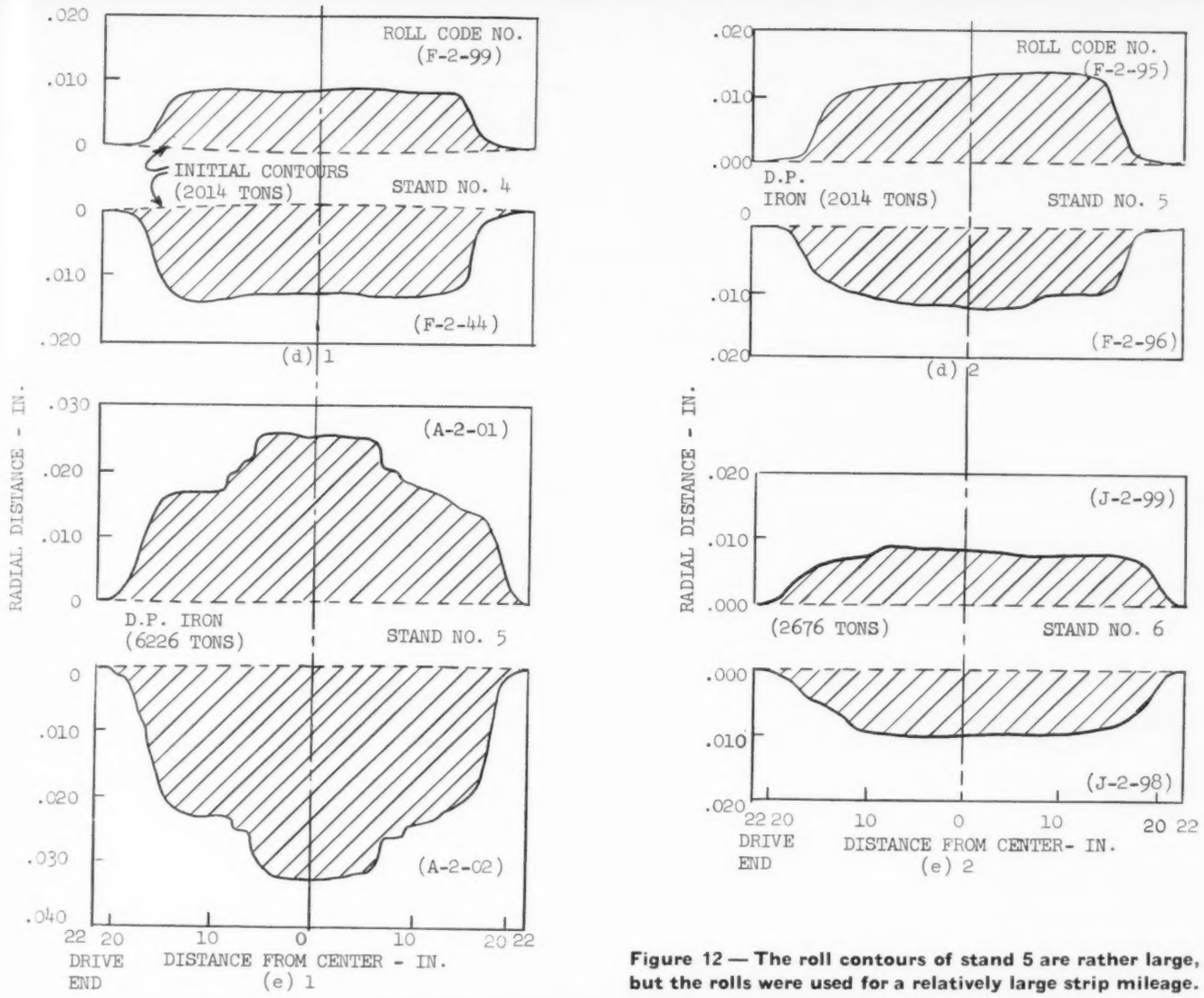


Figure 12 — The roll contours of stand 5 are rather large, but the rolls were used for a relatively large strip mileage.

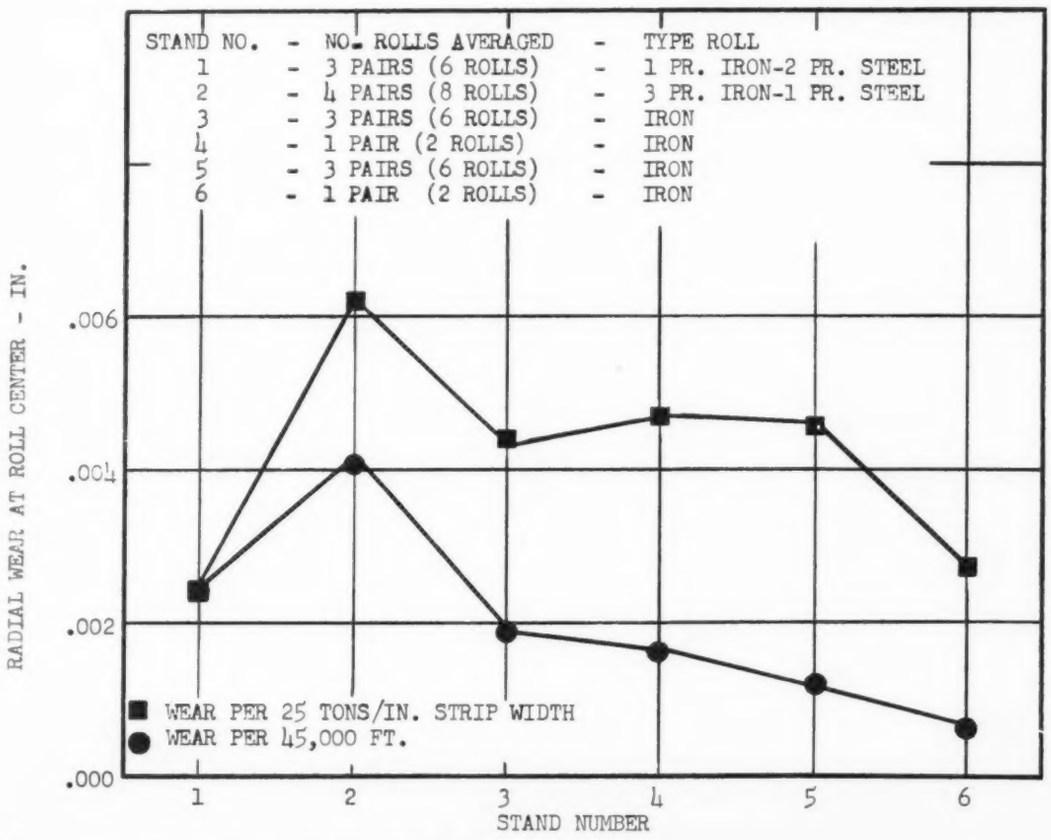
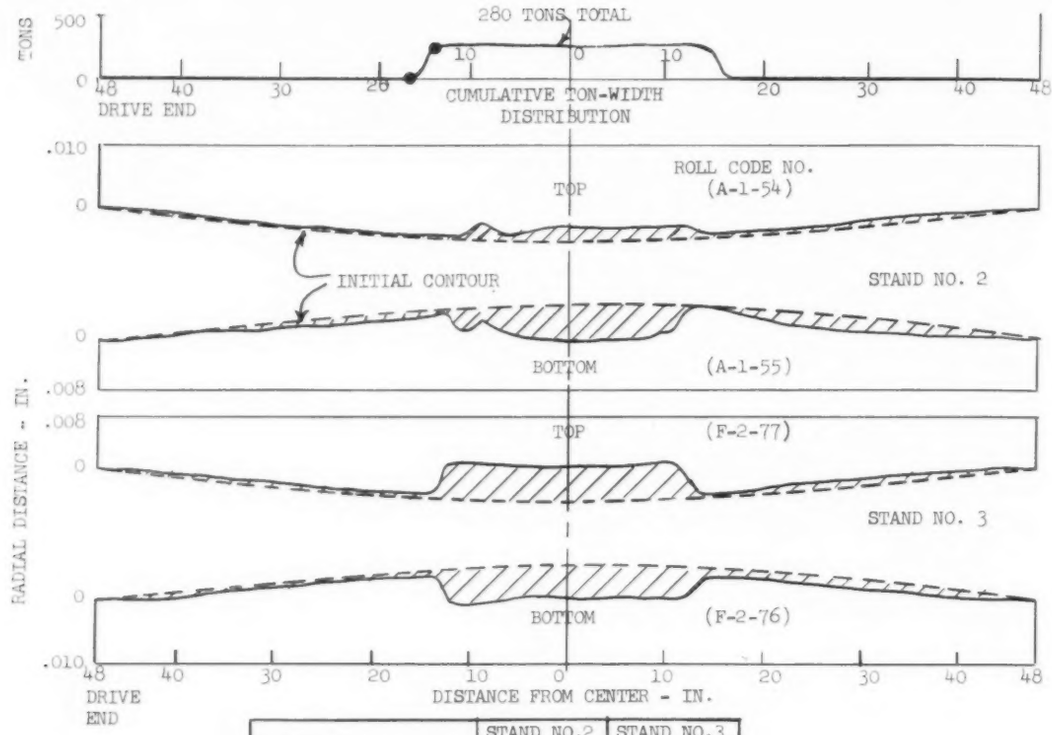

STAND NO. - NO. ROLLS AVERAGED - TYPE ROLL
1 - 3 PAIRS (6 ROLLS) - 1 PR. IRON-2 PR. STEEL
2 - 4 PAIRS (8 ROLLS) - 3 PR. IRON-1 PR. STEEL
3 - 3 PAIRS (6 ROLLS) - IRON
4 - 1 PAIR (2 ROLLS) - IRON
5 - 3 PAIRS (6 ROLLS) - IRON
6 - 1 PAIR (2 ROLLS) - IRON
RADIAL WEAR AT ROLL CENTER - IN.
WEAR PER 25 TONS/IN. STRIP WIDTH
WEAR PER 45,000 FT.
STAND NUMBER

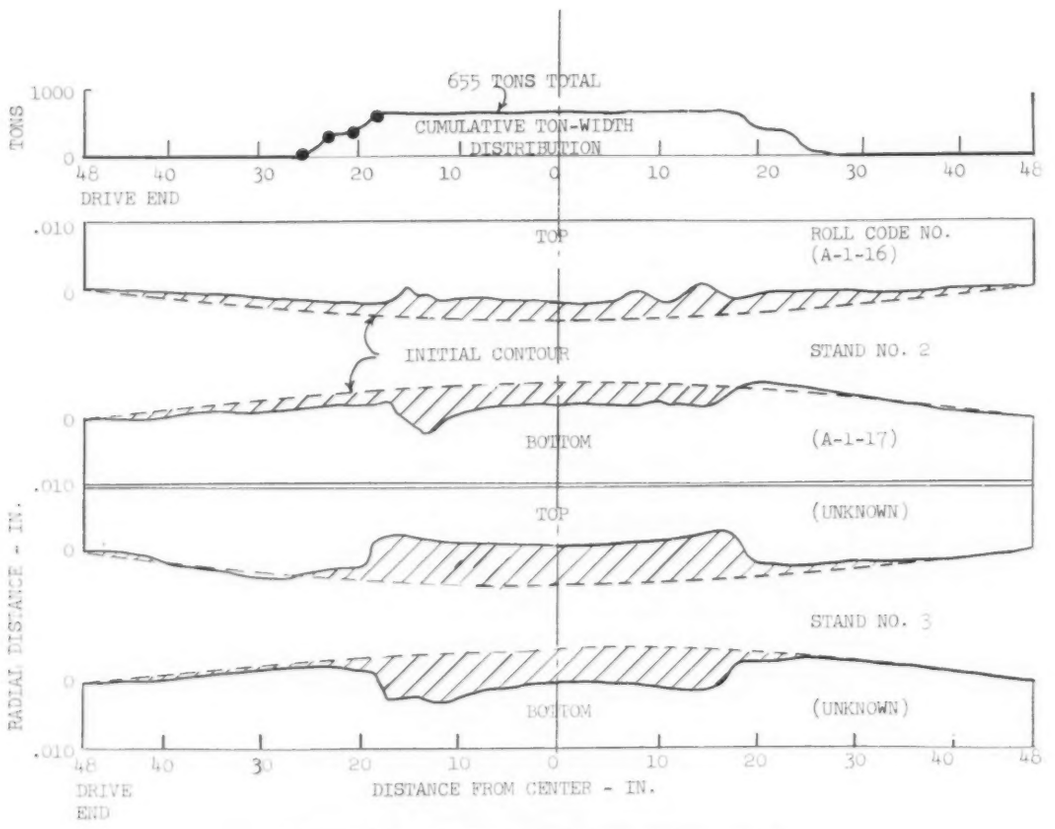
Figure 13 — The roll wear on the 44-in. mill for either a given tonnage or a given mileage is greatest in stand 2.



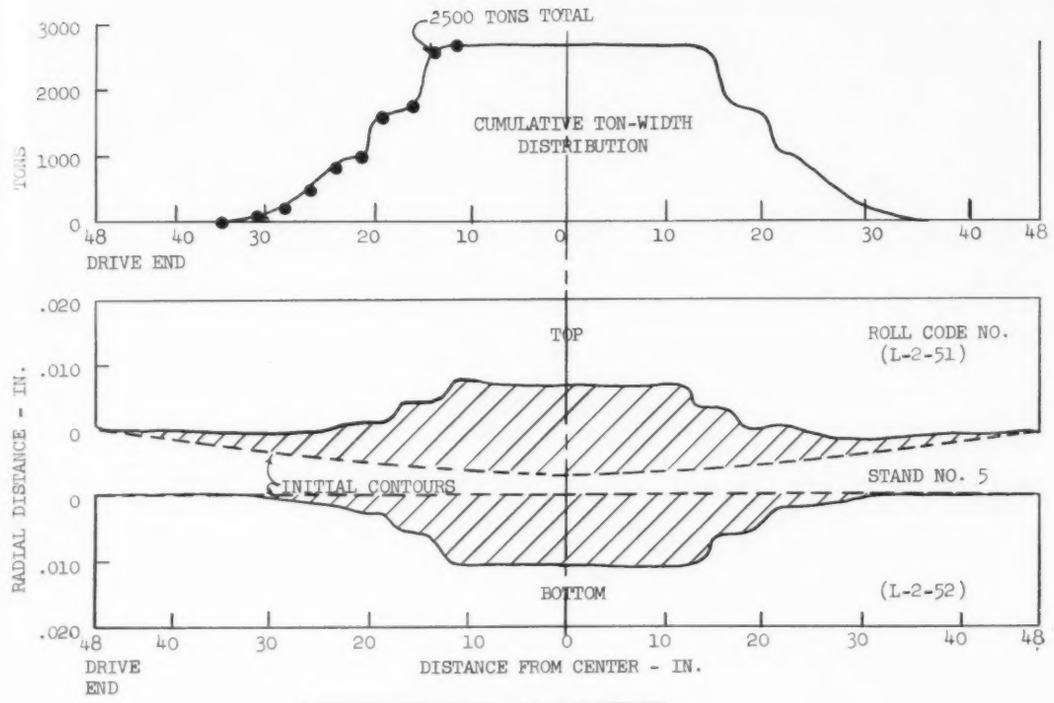
	STAND NO.2	STAND NO.3
ROLL MATERIAL	CAST STEEL	D.P. IRON
HARDNESS - SHORE	P.S.M.492 Mark C	
NOMINAL/TEST DIAM.	27.3/26.0	27.3/25.9
CROWN - DIAM.	.010 CONVEX	.010 CONVEX

Figure 14 — Stands 2 and 3 of the 96-in. mill exhibit the box-shaped roll wear contour.

Figure 15 — The roll wear pattern of stand 2 of the 96-in. mill is rather irregular.

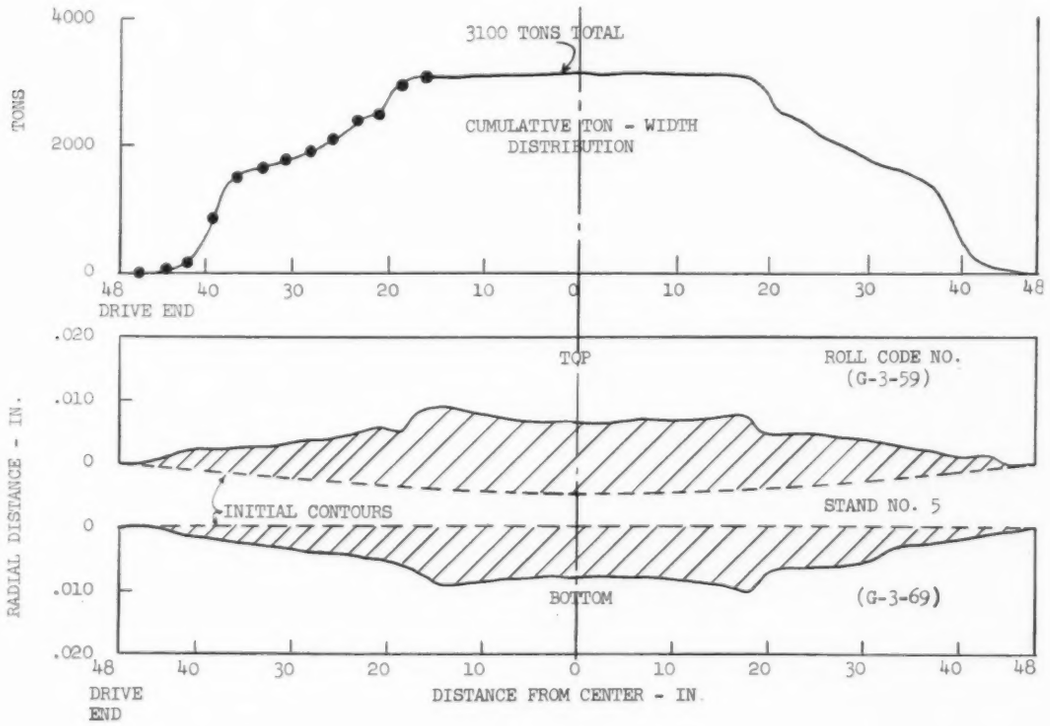


	STAND NO.2	STAND NO.3
ROLL MATERIAL	CAST STEEL	-
HARDNESS	-	-
NOMINAL/TEST DIAM.	27.3/26.2	27.3/26.9
CROWN - DIAM.	.010 CONVEX	.010 CONVEX



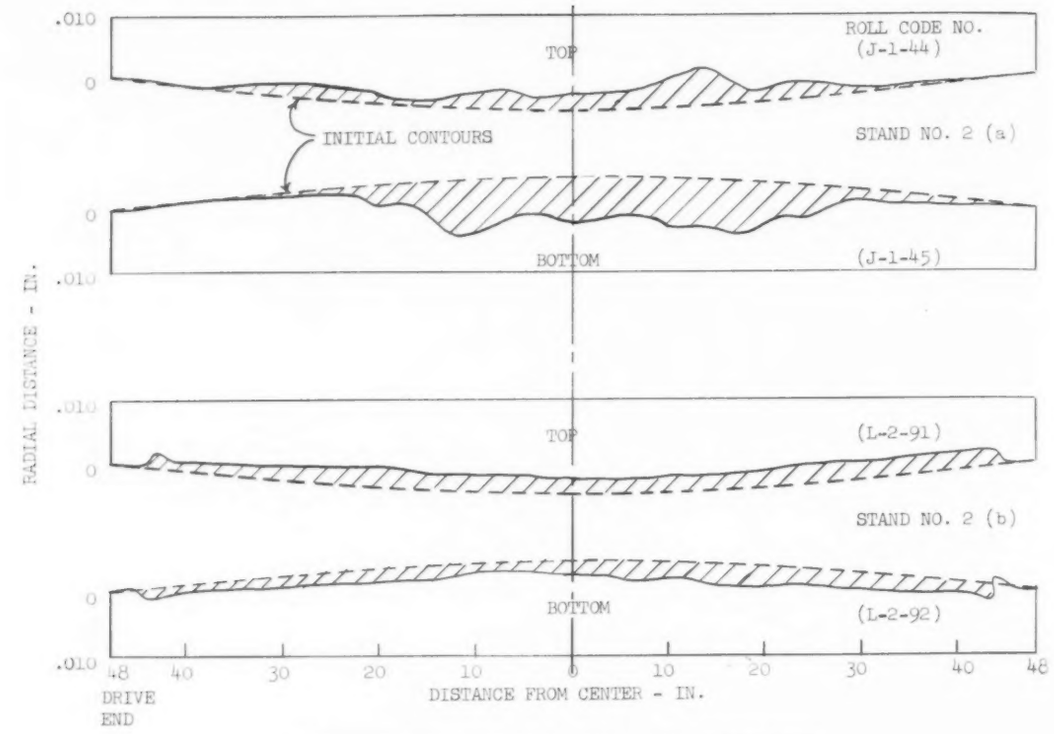
ROLL MATERIAL	D.P. IRON
HARDNESS - SHORE	82/85
NOMINAL DIAM.	27.3
TEST DIAM.	27.1
CROWN - DIAM.	T .014CONVEX
	B 0

Figure 16 — A stepped pattern develops when high tonnages of several widths are rolled.



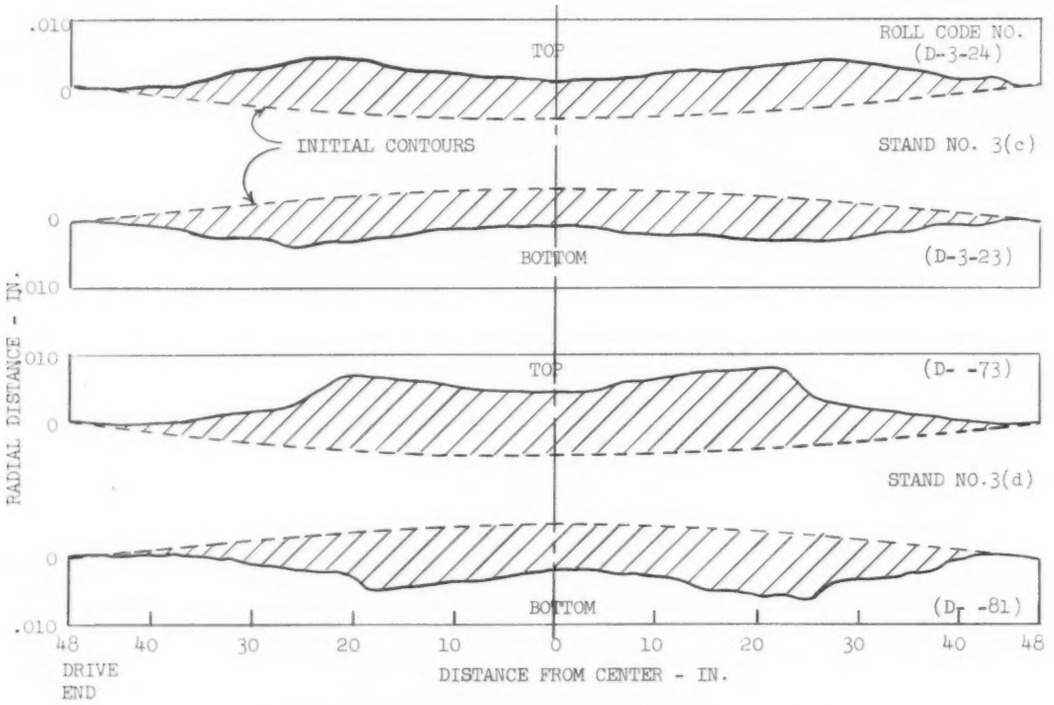
ROLL MATERIAL	D.P. IRON
HARDNESS	-
NOMINAL/TEST DIAM.	27.3/26.5
CROWN - DIAM.	T .010 CONVEX
	B 0

Figure 17 — The rolling of a great number of widths produces a sloping roll wear contour.



	STAND NO. 2 (a)	STAND NO. 2 (b)
ROLL MATERIAL	CAST STEEL	CAST STEEL
HARDNESS-SHORE	-	47
NOMINAL/TEST DIAM.	27.3/25.9	27.3/27.1
INITIAL CROWN - DIAM.	.010 CONVEX	.010 CONVEX
TONS ROLLED	980	185

Figure 18 — Additional roll wear contours of stand 2 of the 96-in. mill are illustrated.



	STAND NO.3(c)	STAND NO.3(d)
ROLL MATERIAL	D.P. IRON	D.P. IRON
HARDNESS-SHORE	83/85	-
NOMINAL/CURRENT DIAM.	27.3/25.7	27.4/26.2
INITIAL CROWN-DIAM.	.010 CONVEX	.010 CONVEX
TONS ROLLED	2300	1185

Figure 19 — Additional roll wear contours of stand 3 of the 96-in. mill are illustrated.

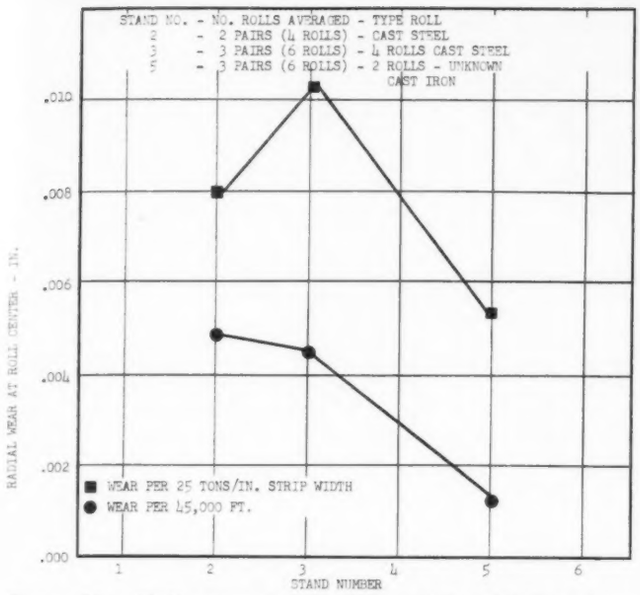


Figure 20 — Roll wears at the center of the roll vs a given tonnage and a given mileage are plotted for stands 2, 3 and 5.

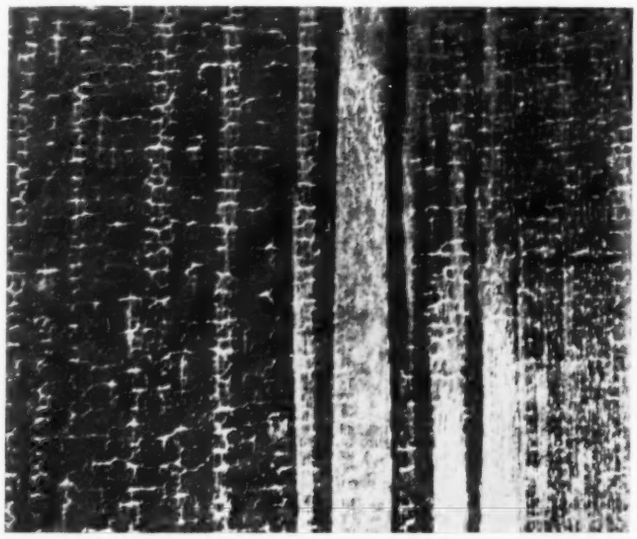
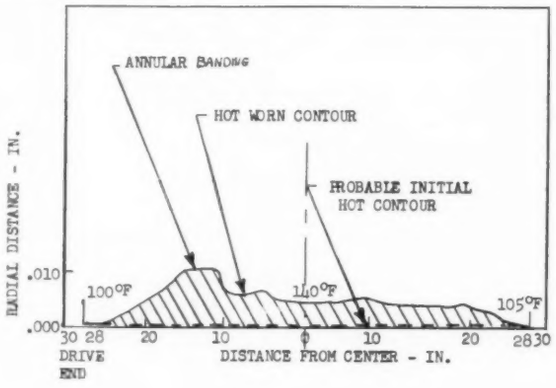


Figure 21 — Fire cracking is evident in the first stand of the hot mill.

Figure 22 — Uneven roll wear contours may be caused by annular banding.



STAND NO. 1	
ROLL CODE NO.	C-2-13
ROLL MATERIAL	D.P. IRON
HARDNESS-SHORE	75/80
NOMINAL/TEST DIAM.	
INITIAL CROWN - DIAM.	.007 CONCAVE
TONS ROLLED	1670

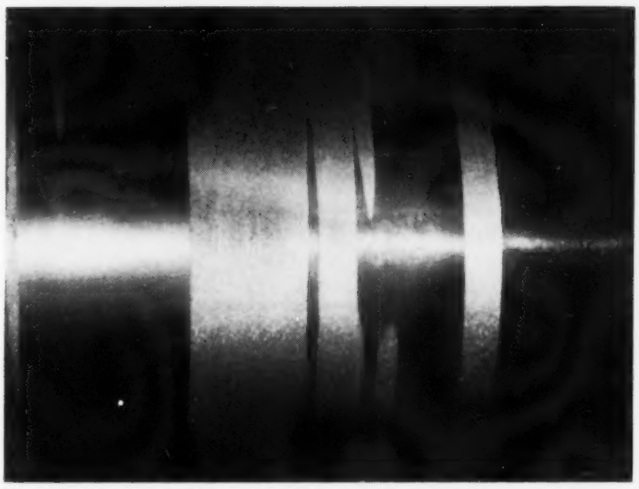


Figure 23 — Banding and skin spalling produce an irregular wear pattern.

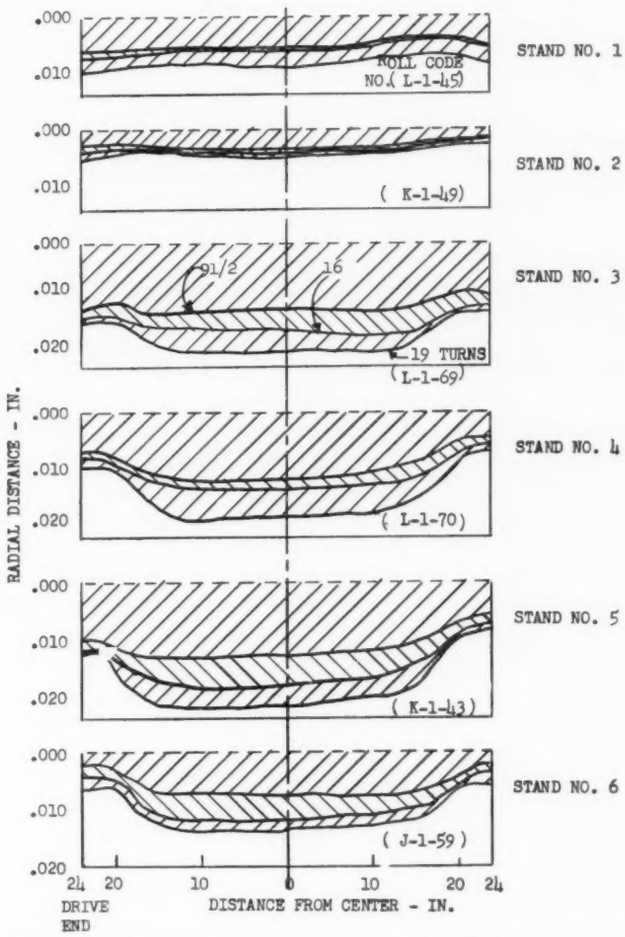


Figure 24 — The wear contours of the top backup rolls of the 56-in. mill are illustrated after 9½, 16 and 19 operating turns.

roll length. However, in the other stands, box-shaped depressions occur in the wear patterns which appear to be contoured similar to, although slightly narrower than the cumulative ton-width distribution, see Figure 25. Furthermore, the contour of this cavity is generally smooth and probably consistent for each stand, primarily because the rolling program should be also consistent for each backup roll work cycle.

The amount of wear at the center for a given tonnage, according to Figure 28, decreases noticeably from stand

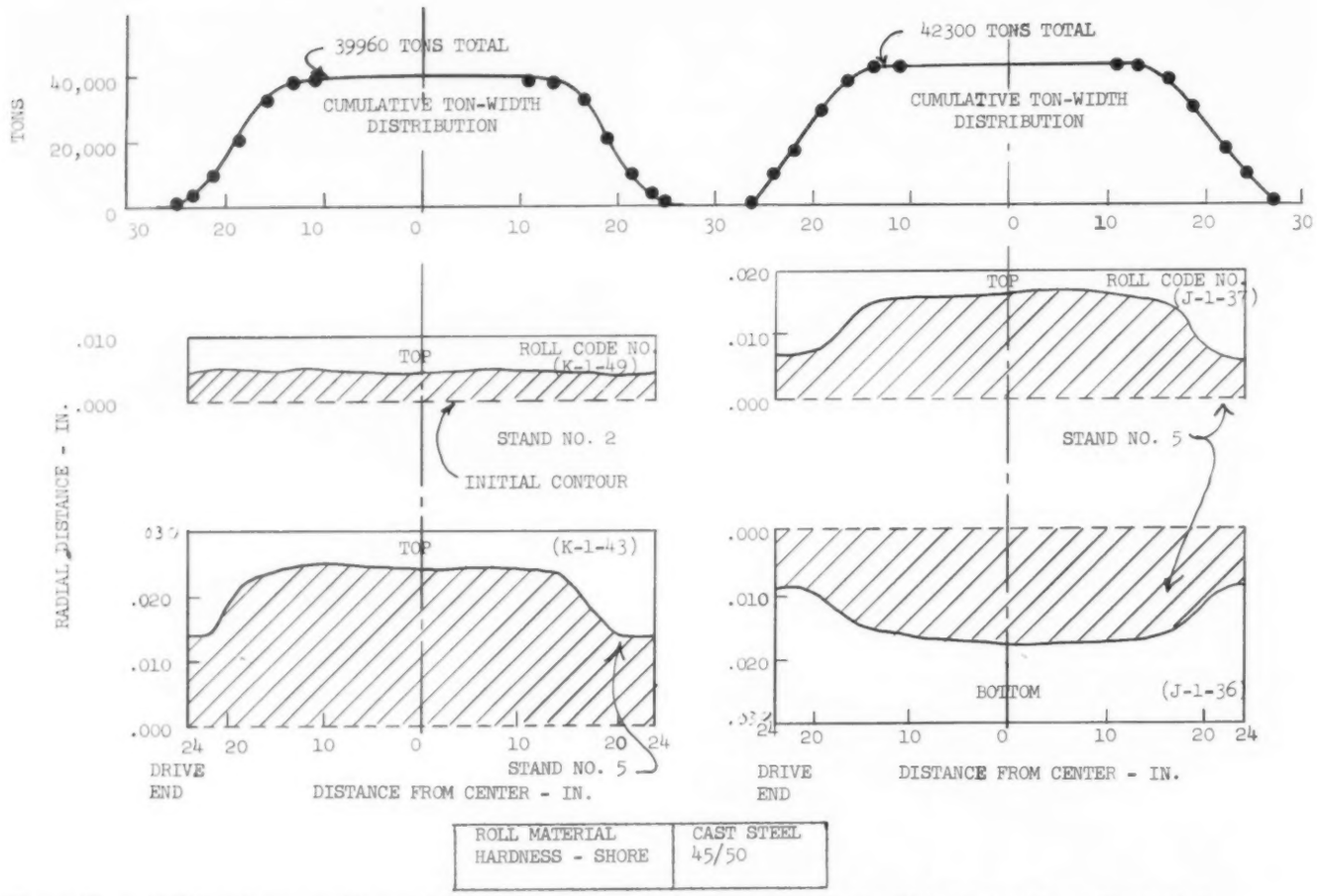


Figure 25 — Additional wear patterns of the backup rolls for stands 2 and 5 of the 56-in. hot mill are illustrated.

1 to stand 2, increases greatly to a maximum at stands 4 and 5 and then decreases to a considerably lower value for stand 6.

Previous wear data for one set of rolls reported by Sibakin, Ride and Sherwood[6] are shown in Figure 29, calculated from their data on the assumption that their average strip width was the same as in the present tests. The wear for a given tonnage reported by these authors was considerably less than that determined in this investigation as they considered only the depth of cavity. If the depth of cavity only is considered, the two sets of data agree closely.

The amount of wear at the roll center for a given mileage is found to be about the same for stands 1, 3 and 4 and less than one half of these values for stands 2 and 6, see Figure 28.

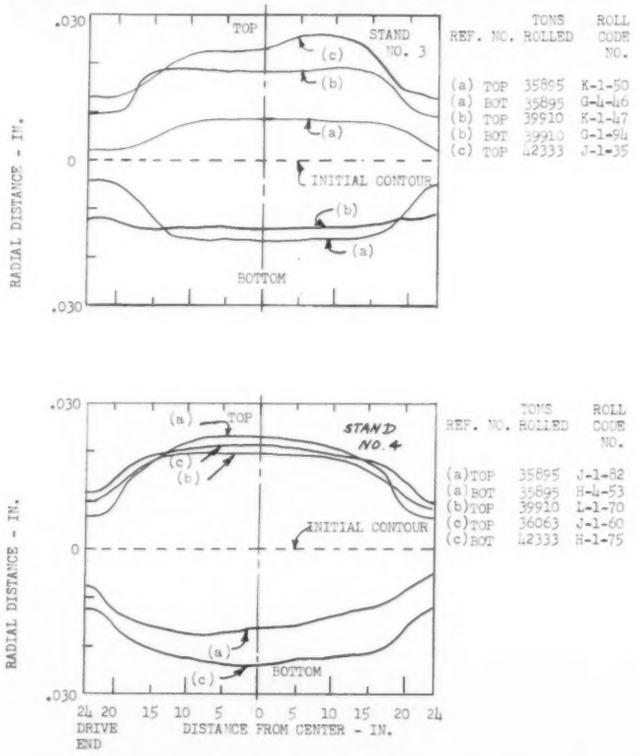
Figure 30 illustrates the progress of wear with time both at the center and near the necks (average of the readings on each side, 23 in. from the center) of all top rolls of the 56-in. hot finishing train, obtained from the wear patterns in Figure 27. Generally, the rate of wear is found to decrease slightly with progressive rolling, possibly due to the work hardening of the backup roll surface. Exceptions are the locations near the necks of the rolls of stands 2 and 6, which apparently wear at nearly the same rate during the entire rolling cycle.

The 44-in. mill—For this mill only one set of data is available, covering, according to Figure 31, only stands 3 to 6. These wear patterns exhibit only slightly higher wear in the center than at the edges of the rolls.

The amount of wear at the roll center for a given tonnage, presented in Figure 32, indicates nearly equal wear for stands 3 to 6.

Correspondingly, the amount of wear for a given

Figure 26 — Top and bottom backup roll patterns for stands 3 and 4 of the 56-in. mill are illustrated.



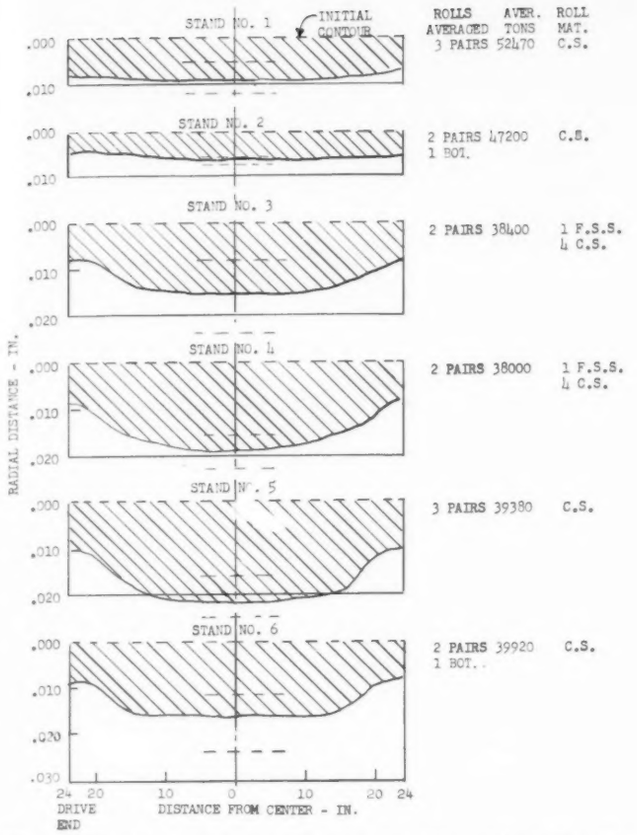


Figure 27 — An average roll wear contour pattern for the 56-in. mill backup roll is illustrated.

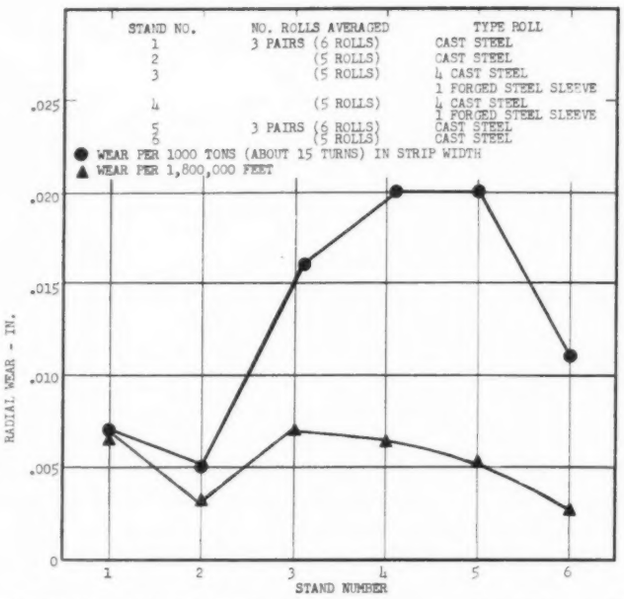

STAND NO. NO. ROLLS AVERAGED TYPE ROLL
1 3 PAIRS (6 ROLLS) CAST STEEL
2 (5 ROLLS) CAST STEEL
3 (5 ROLLS) 4 CAST STEEL
1 FORGED STEEL SLEEVE
4 (5 ROLLS) 4 CAST STEEL
1 FORGED STEEL SLEEVE
5 3 PAIRS (6 ROLLS) CAST STEEL
6 (5 ROLLS) CAST STEEL
WEAR PER 1000 TONS (ABOUT 15 TURNS) IN STRIP WIDTH
WEAR PER 1,800,000 FEET
RADIAL WEAR - IN.
STAND NUMBER

Figure 28 — Maximum backup roll wear on the 56-in. mill occurs in stands 4 and 5.

mileage decreases progressively from stands 3 to 6.

The 96-in. mill—The very limited data (Figure 33) available for this mill indicates nearly uniform wear of the backup rolls along the entire contact length, although the pattern is irregular in several instances.

The amount of wear at the roll center for a given tonnage is, according to Figure 34, only slightly different for stands 2, 4 and 5, but in all cases considerably greater than for stand 1.

The amount of wear at the roll center for a given

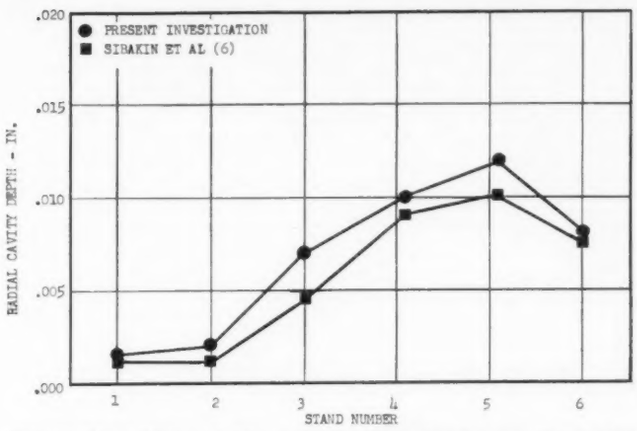


Figure 29 — Wear at the center of the backup rolls of the 56-in. hot mill after 20 turns is illustrated.

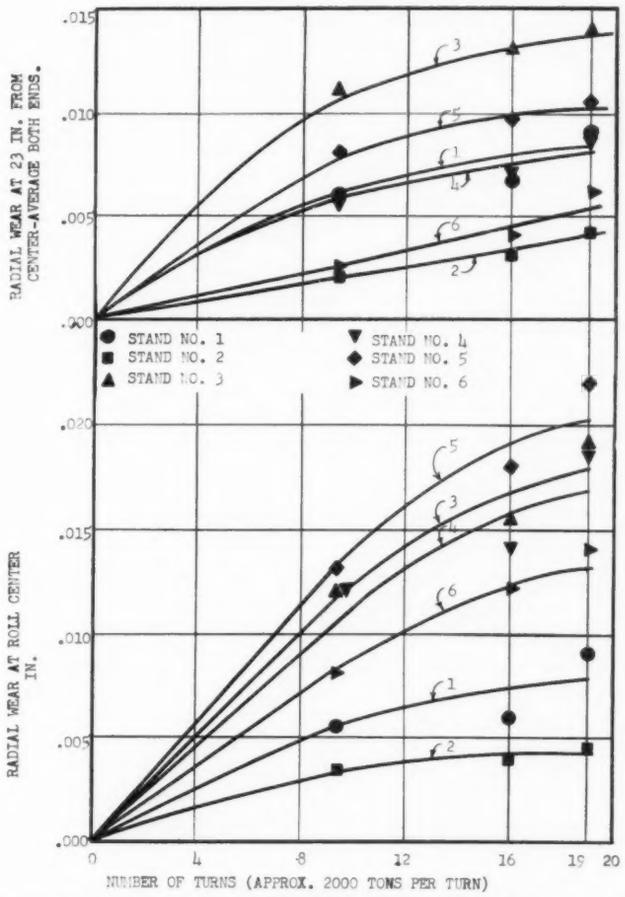

RADIAL WEAR AT 23 IN. FROM CENTER-AVERAGE BOTH ENDS.
STAND NO. 1
STAND NO. 2
STAND NO. 3
STAND NO. 4
STAND NO. 5
STAND NO. 6
RADIAL WEAR AT ROLL CENTER IN.
NUMBER OF TURNS (APPROX. 2000 TONS PER TURN)

Figure 30 — Wear progress of the backups of the 56-in. mill is plotted vs turns rolled.

mileage correspondingly increases from stand 1 to stand 2 and then decreases to stands 4 and 5.

WEAR OF THE WORK AND BACKUP ROLLS OF A COLD MILL

Contour measurements were also made on the work rolls of the 5-stand, 56-in. cold mill. According to Figure 35, the wear of the work rolls during a normal cold mill cycle is very small, and exceeds only slightly the accuracy of the measurements. An exception may be the rolls of stand 1, which developed a shallow, somewhat irregular box-like depression. The rolls of stand 1 were cooled with cold water whereas the rolls in stands

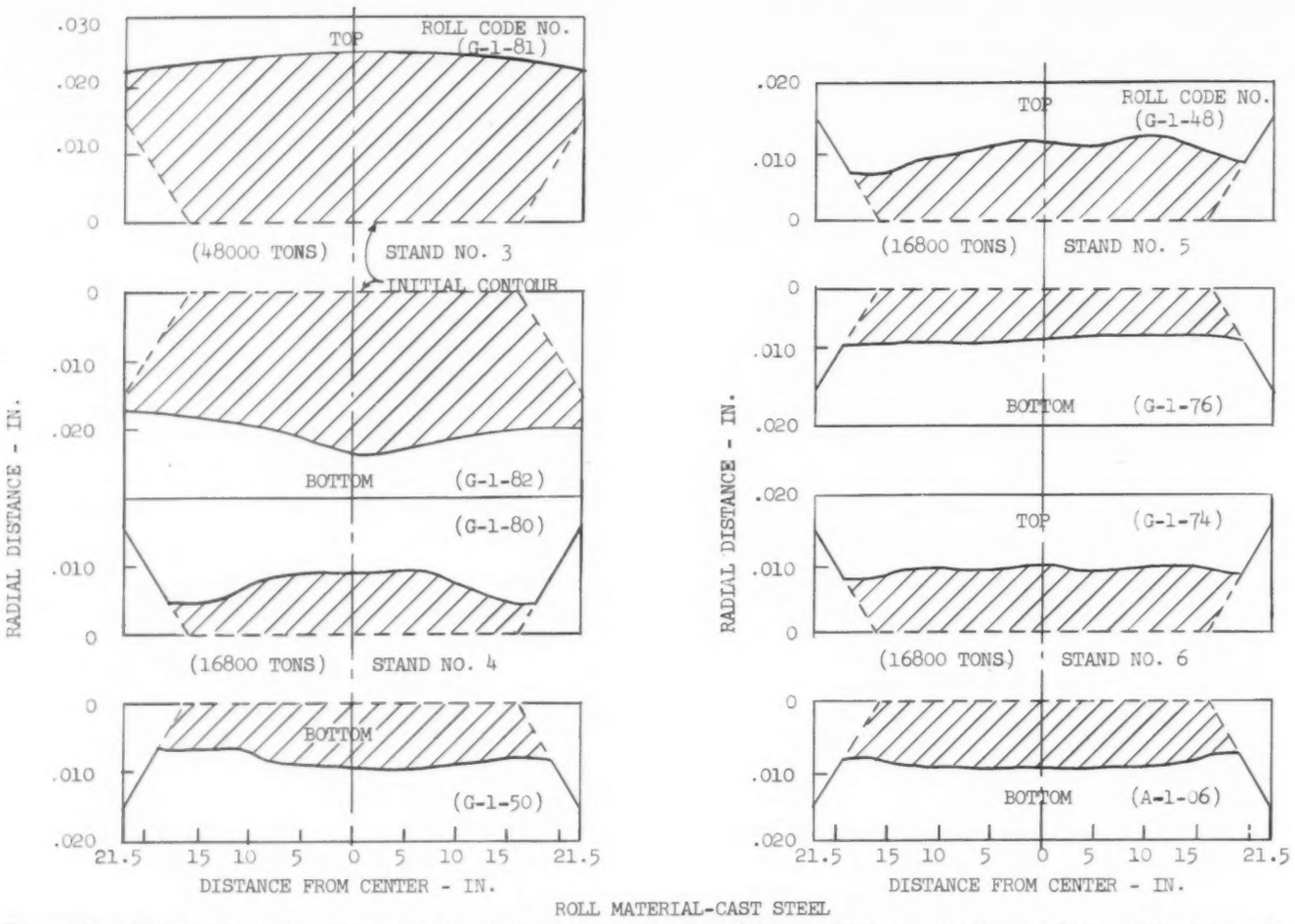
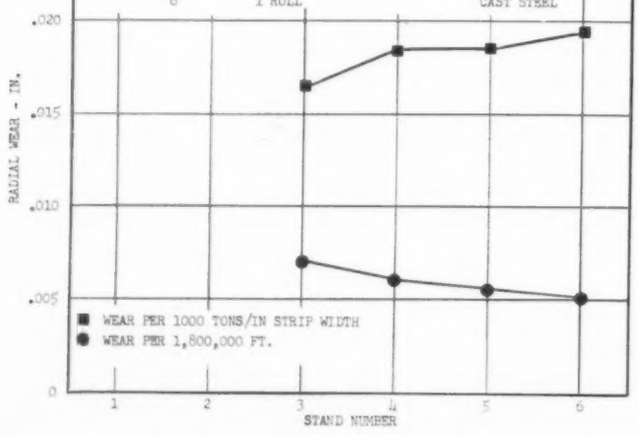


Figure 31 — The backup roll contours of the 44-in. mill were developed from micrometer readings taken at 5-in. intervals.

2, 3, 4 and 5 were lubricated with a warm soluble oil emulsion.

Regarding the wear of the backup rolls of the cold tandem mill, no reliable measurements were obtained, again because the amount of wear during a normal cycle is close to the accuracy of the measurements. The recorded contours were in all instances nearly flat and showed some local irregularities, probably as a result of wrecks. The only definite indication of wear has been observed in stand 5 which had an initial radial convexity to 0.0025 in. but which after rolling showed a concavity in two instances.

Figure 32 — Backup roll wear of the 44-in. mill per given mileage or given tonnage is relatively constant for stands 3, 4, 5 and 6.



SUMMARY

The results of measurements of the wear encountered in the rolls of different hot finishing trains of steel strip mills clearly reveal the complexity of the problem. Even though the dependence of wear on the numerous variables of the rolling process is not fully disclosed by the experimentation conducted to date, it appears that a number of facts and relations can be generalized and considered to be reasonably well established.

1. Regarding the wear of the work rolls of hot finishing trains, the following general observations were made:

The wear patterns in all except the first two stands are clear images of the rolling schedule. A schedule which comprises rolling a large variety of strip widths usually results in a depression of the form of a box with walls sloping between the extreme edge positions of the various strip widths. Any increased rolling of strip of a given width develops a step in this wear pattern.

The bottom of this box appears to be nearly straight or slightly concave in the narrow and intermediate mills. Concavity should result from the thermal expansion or "puffing" of the rolls during service which would cause a convex curvature. On the other hand, roll flattening and bending under the pressure necessary

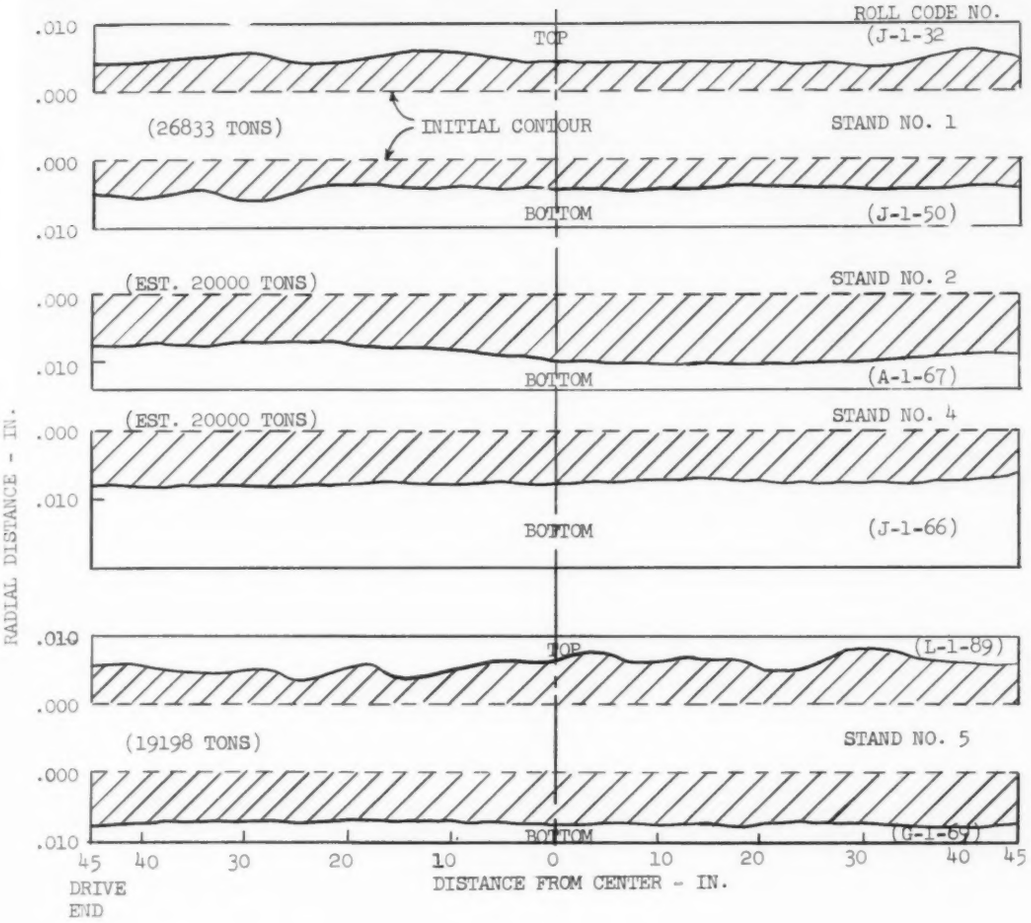


Figure 33 — Backup roll wear contours of the 96-in. mill were developed from micrometer readings taken at 5-in. intervals.

to roll the strip should cause a distortion reverse to that of puffing. In addition, as this pressure increases from the edge to the center of the strip, increased wear may be expected to occur in the center of the bottom of the wear pattern.

The bottom of the wear pattern is distinctly convex in the wide mill, which indicates considerable bending of these rolls during rolling.

The frequency of irregularities in the wear patterns decreases from the first to the last stand. Usually quite symmetrical wear patterns are observed in stands 5 and 6, and rather frequently irregular patterns are observed in stands 1 and 2.

The wear patterns in stands 1 and 2 vary widely from mill to mill. Excessive wear near the edges of the wear pattern appears to be associated with banding.

The amount of wear in stands 1 and 2 varies greatly from mill to mill. It appears generally to increase from stand 1 to stand 2, and in the latter stand it may be, for a given mileage, either greater or smaller than in stand 3.

The magnitude of wear for a given mileage generally decreases progressively from stand 3 to stand 6.

The differences in the magnitude of wear for top and bottom work rolls respectively were inconsistent and varied with the mill.

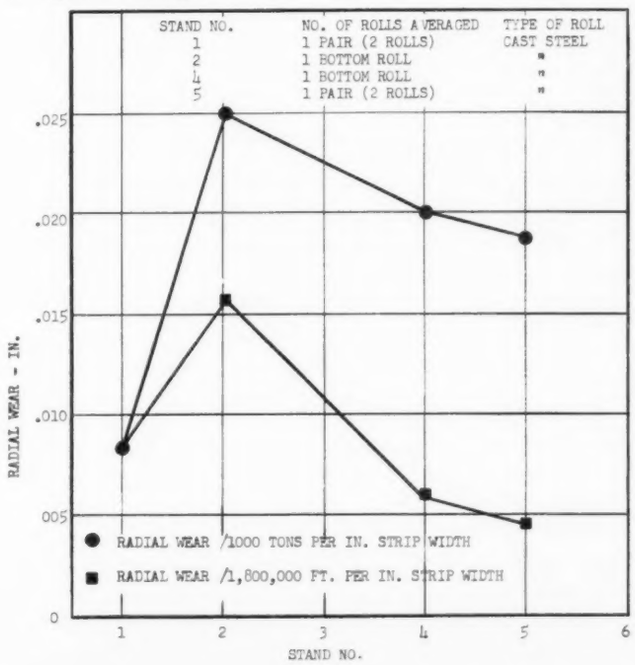
A difference in the magnitude of wear for cast-steel and cast-iron work rolls respectively could not be definitely established.

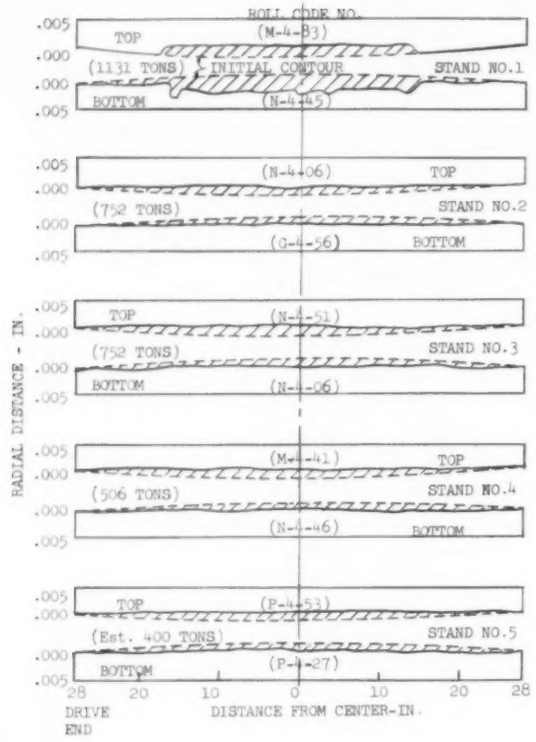
2. The wear of the backup rolls of hot finishing stands has been systematically studied, primarily for the intermediate mill. The following results also apply to the other mills, where sufficient information is available:

Wear occurs over the entire length of the rolls.

The wear of the rolls of stands 1 and 2 is nearly uniform over the entire length with slight irregularities frequently encountered.

Figure 34 — Backup roll wear in stand 2 of the 96-in. mill is greater than that for stands 1, 4 or 5 for a given tonnage or a given mileage.


STAND NO. | NO. OF ROLLS AVERAGED | TYPE OF ROLL
1 | 1 PAIR (2 ROLLS) | CAST STEEL
2 | 1 BOTTOM ROLL | "
4 | 1 BOTTOM ROLL | "
5 | 1 PAIR (2 ROLLS) | "
.025
.020
.015
.010
005
0
RADIAL WEAR - IN.
RADIAL WEAR /1000 TONS PER IN. STRIP WIDTH
RADIAL WEAR /1,800,000 FT. PER IN. STRIP WIDTH
1 2 3 4 5 6
STAND NO.



STAND NO.	1	2	3	4	5
ROLL MATERIAL	FORGED STEEL	FORGED STEEL	FORGED STEEL	FORGED STEEL	FORGED STEEL
HARDNESS-SHORE	REHARD.	95/98	92/94	92/94	-
CROWN-DIAM.	.003 CONVEX	.003 CONVEX	.003 CONVEX	.003 CONVEX	.003 CONVEX

Figure 35 — Work roll wear in the cold mill is normally small.

The wear in stands 4 to 6 is usually greater in the center than at the edges, with some indication of a depression similar to that of the respective work roll, but with the maximum wear at the roll center generally less than twice the wear at the roll edges.

The amount of wear in stands 1 and 2 varies greatly from mill to mill, with the greatest wear occurring in either of these stands for a given mileage.

The magnitude of wear for a given mileage decreases progressively from stand 3 to stand 6.

The rate of wear of backup rolls is only a small fraction of that of the respective work roll.

3. The normal wear of either the work rolls or the backup rolls of a 56-in., 5-stand tandem cold strip mill has been found to be very light, except for stand 1. Roll changes in the cold mill are made as a result of surface defects which are imparted to the strip, rather than as a result of change of shape due to wear.

CONCLUSIONS

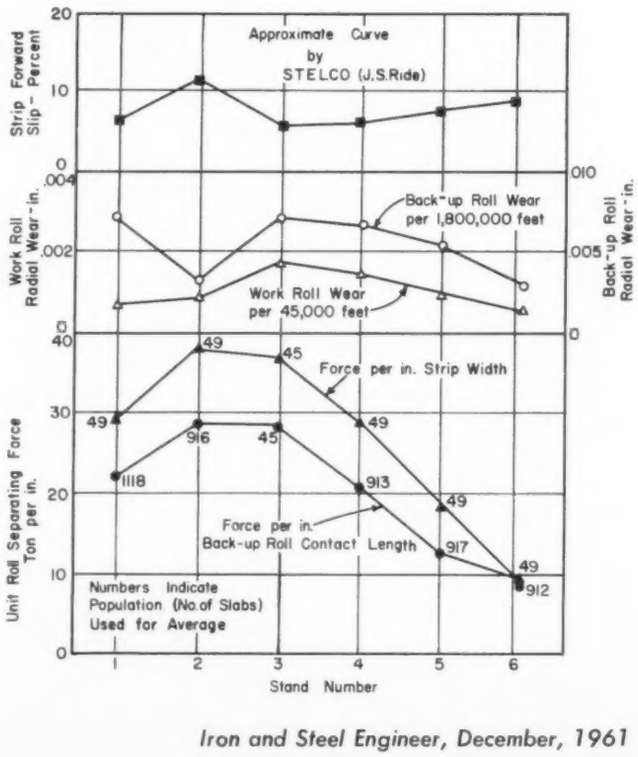
It is clearly revealed by the present investigation that the wear of work rolls greatly exceeds that of the backup rolls. This can be attributed to the much higher friction coefficient, as well as the much larger slippage between the strip and work roll surfaces than between the backup and work roll surfaces. Also, there are about twice as many contact cycles of the work roll per unit of strip than on the backup roll. Among factors which determine the magnitude of wear of either work or backup rolls, the roll separating force is the most lucid and most readily available. In comparing wear and pressure, the results of this investigation suggest that wear for a given mileage is a suitable base unit for wear. In turn, the roll separating force per unit width should be a suitable base unit for the load. For the work roll, the strip width and for the backup roll the cylindrical contact length should be used as width in this relation.

A comparison of such unit wear and roll separating force data obtained in this investigation (Figure 36) surprisingly reveals that wear and force are subject to much the same fluctuations from stand to stand. This comparison applies to both the work rolls and the backup rolls, and indicates that the roll separating force is the dominating factor regarding wear, and that the influence of other factors is probably lost within the accuracy of the test data.

Previous investigations on roll wear considered primarily its effect on the contour of the finished strip, Ehmicke,[2] Sibakin, Ride and Sherwood[6] and Christoph and Griffin.[9] Of particular practical and fundamental importance are two facts: (1) that the profile of the cold finished strip is dependent on that of the hot finished strip;[6,9] and (2) that the crown of the strip increases with progressive wear of the backup rolls.[9]

From the observations made to date, roll spalling is generally a fatigue problem. The stress state and stress distribution leading to fatigue possess several components: (1) the residual stresses retained from casting or heat-treating; (2) the stresses resulting from heating of the rolls; and (3) the stresses caused by the roll separating force on the pressure between metal and working roll. In addition, very high momentary stresses may result from cobbles or wrecks causing extreme local heating and stressing.

Figure 36 — A comparison of roll wear with average unit separating force on the 56-in. hot mill reveals a stand to stand fluctuation.


Strip Forward Slip - Percent
Approximate Curve by STELCO (J.S.Ride)
Work Roll Radial Wear - in.
Back-up Roll Radial Wear - in.
Back-up Roll Wear per 1,800,000 feet
Work Roll Wear per 45,000 feet
Force per in. Strip Width
Unit Roll Separating Force Ton per in.
Force per in. Back-up Roll Contact Length
Numbers Indicate Population (No.of Slabs) Used for Average
Stand Number

According to practical experience, the work rolls are particularly subject to cracking by thermal shock or thermal fatigue within a few revolutions of the rolls. Furthermore, the regular occurrence of fire cracking in the first few stands of the hot finishing train indicates that the variations in temperature and the stresses resulting from them are another primary source of surface damage. As the strip moves from stand to stand, the influence of the normal temperature variations on the roll surfaces decreases and the variations in the pressure resulting from the rolling assume increased significance. Therefore, the cycle of a work roll may be determined by a variety of phenomena leading to surface damage. Wear itself is another factor which may lead to replacement of a roll because of its undesirable effect on the strip profile. The failure of a work roll, therefore, is an extremely complex and variable phenomenon.

In contrast, the spalling of backup rolls presents a more uniform appearance. The continuation of this project will be devoted, therefore, primarily to the analysis of the spalling and fatigue of backup rolls.

The fatigue of the backup roll, and possibly also that of the work roll, are much the same phenomena as those of ball and roller bearings, which have been studied in some detail by Butler, Bear and Carter,[10] Bear and Butler[11] and Butler and Carter.[12] Unfortunately, these investigations appear to be limited to ball bearings which comprise a considerably simpler problem than rolls in contact under pressure. However, the basic result of the tests on ball bearings, that fatigue failures by spalling will occur under high applied pressures, remains also the principal assumption in any attempt to explain spalling of the backup rolls.

These pressures depend primarily on two factors, the roll separating forces and the roll contour during rolling. According to Figure 32, the roll force per in. of roll contact length may reach, in stands 2 and 3, an average value of about 60,000 lb per in. or the average unit pressure (Hertz pressure) may reach a value of about 210,000 psi maximum.

Even with perfectly cylindrical rolls the unit pressure is not uniformly distributed along the roll length but is concentrated in the center portion. Such a pressure distribution is present, at the beginning of the rolling, although initial crowning, roll expansion, bending and flattening make the roll contact area curved. The pressure concentration in the roll center is apparently maintained during a substantial portion of the cycle for the backup roll, as its wear is generally found to be greater in the center than at the edges of the roll. On the other hand, the presence of substantial wear of the entire roll surface indicates rather intimate contact of the two rolls during most of the rolling cycle.

However, as the wear of both the work roll and the backup roll progresses, the pressure peak in the center could be replaced by two pressure peaks in the vicinity of the sharp corners of the wear pattern.

Regarding the effect of the contour changes on the pressure distribution, a preliminary calculation by Keller[13] indicates that the force per unit length could readily assume a maximum value of twice the above mentioned base value (for uniform distribution). The starting value for slightly crowned rolls has apparently not yet been determined. The next problem to be studied in this connection, therefore, will be the calculation of the load distributions and the resulting stresses in relation to the changes in roll contour during rolling. At the same time the properties of the material and particularly its fatigue behavior under simulated rolling conditions will be determined.

The ultimate objective of these studies is an increase in roll life by reducing the incidence of spalling. It appears clear from the present investigation that roll wear should be controlled to produce the lowest and most uniform load distribution possible. On the other hand, the factors leading to increased wear and fatigue resistance of the roll materials should be explored. Furthermore, the dressing procedure may be another important factor, as it may remove a damaged surface layer or shift the focus of the subsurface stresses which may be responsible for failures.

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Discussion

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Louis Such: On the charts shown, the profile of the roll "as ground" seems to have been dubbed in. Were they the actual profiles of the rolls? In other words, how close is the Gilbertson-Thomas gage to the theoretical ground shape, and how well could the measurements be reproduced by the camber gage?

The authors made reference to slippage between the backup and work rolls. What relative difference was detected between the circumferential speed of the work and backup rolls, under load, with the pulse tachometer that was used? Did this vary in the same proportion as the roll wear did?

In the authors' closing remarks they stated that it appears clear from the present investigations that roll wear should be controlled to produce the lowest and the most uniform load distribution possible. Just what type of specific control would the authors suggest? Obviously, the loading of the stands to produce an end product of specified thickness can be varied only within limited degrees.

Reference also was made to an abnormal drop-off in wear near the end of the backup rolls. This is not always an actual case of loss in material, that is, a diminishing of the roll diameter, but is rather a displacement of metal, an actual upsetting. It can be readily detected upon comparison with a normally ground roll, which has a chamfer at the edge of the roll barrel.

Dr. George Sachs: When one speaks of slip one has to distinguish between one of at least four types that are likely to exist: (1) there is slip between the work roll and the metal; (2) there is the differential slip encountered between some portions of the work roll and the backup roll due to the fact that neither is perfectly cylindrical; (3) there is elastic slip resulting from roll flattening; and (4) there may be slip or skidding between the work and backup roll as one roll transfers force to the other roll. It is the latter which it was felt could be detected with the pulse tachometer. While preliminary tests suggested that there might be a significant amount of slip, later and more thorough tests did not support this. At least this was true for the fifth finishing stand on which the tachometer was installed. Very little is known about the various kinds of slips at the present time.

It is obvious that the soft backup roll, when it fatigues, is subjected to plastic strains. In other words, it cannot fatigue before the shear strain is repeated in the area where it will break. This, of course, may be very well related to the lateral displacement of some of the metal which in our graphs may appear as wear.

In connection with control to obtain the lowest and most uniform load distribution, control of the rolling schedule to produce maximum tonnage with minimum gap (wear) development is desirable. The cumulative ton-width distribution curves can assist in programming the schedule to a point where one can predict when the maximum allowable wear will occur, and the roll can be removed for dressing on a schedule rather than as strip quality dictates. Otherwise one may end up, trying to fit a strip into a wear pattern that cannot produce flat sheet, by continuing rolling when the pressure distribution is most unfavorable.

James V. Latorre: Abnormally low wear at the ends of the backup rolls and upsetting of roll material was observed particularly in the narrow and intermediate mills and was most obvious in the narrow mill.

Relative to the control of wear, consideration is being given to the lubrication of hot mill rolls in some manner. If this can be accomplished, wear should be considerably reduced. It has been reported that the British are performing some experiments with colloidal graphite at the present time. Another more obvious but probably more difficult method to reduce roll wear is to increase the wear resistance properties of the roll material.

The Gilbertson-Thomas roll camber recorder is not only an accurate but a practical method of obtaining roll contours. In order to prove this a comparison was actually made of the contour recorded with the contour indicated by a "traveling indicator" which seems to be the standard tool of roll grinders for checking ground contours. The recorded contour was within 0.0005 in. of the indicated contour, and this is the limit of the accuracy to which one could read the recorded chart. In the early tests, the ground contour was determined from the mill's roll record cards. After finding several discrepancies such as larger worn roll diameters (after cooling) than those reported on previous dressings and some ground contours not as reported on record cards, measuring of all rolls before they were put into the mill was initiated. The as-ground contours dubbed in on the curves represent both mill reported contours that did not measure (corrected where the error was obvious) and the measured contours.

A. A. Bradd: The conclusion that more tons between grinds and less reduction per grind results in greater frequency of roll surface damage and increases in large diameter reductions, probably because of spalls, is worth more attention than it appears to be getting in many mills.

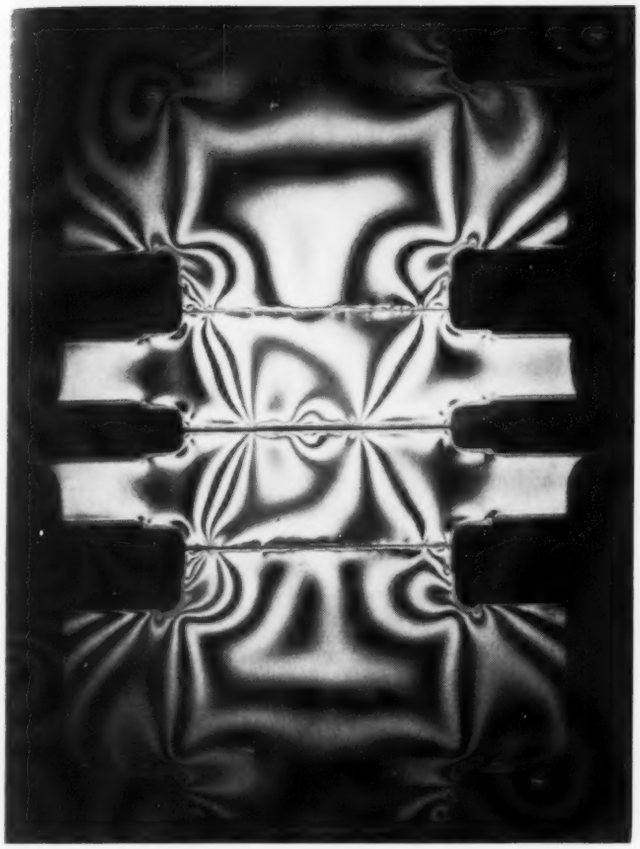

Figure 37 — A photo-elastic stress distribution with the strip centrally located is illustrated.

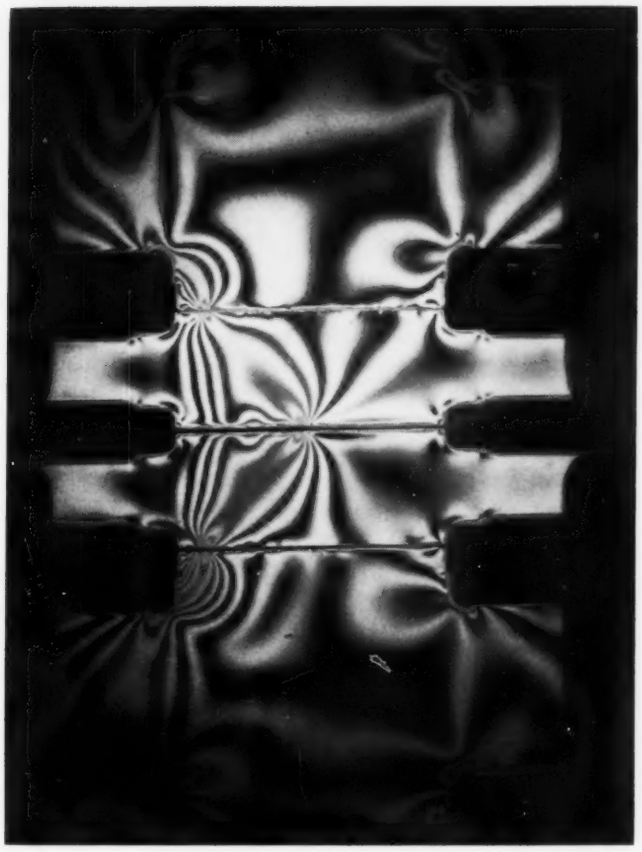

Figure 38 — A photo-elastic stress distribution with the strip offset to the left is illustrated.

Reducing the body diameter of a roll to merely clean up visible surface damage without specifying a minimum stock removal, could leave heavily cold worked material on the rolling surface and high residual stresses. The combination of the embrittling effect of the cold work and the high residual stress pattern could produce a marked decrease in resistance to spalling.

With this practice, a soft roll with less resistance to marking and wear could give better tonnage than a hard roll that would maintain its surface finish and shape, but would have less reduction per grind because grinding is done only to remove surface damage, while the softer roll, with deeper surface damage, would require more reduction to clean up the surface.

The reported Hertz compressive stresses of 210,000 and 270,000 psi figured on uniform load distribution and the estimated stresses ranging as high as 420,000 to 540,000 psi with nonuniform load distribution, are quite high and could easily account for some of the spalls.

Backup rolls taken out of hot mills have been seen where the wear pattern suggested that only one third of the contact area was actually supporting the load. This suggests that the actual load on the roll was three times as high as the load based on uniform load distribution.

A factor affecting load distribution on rolls is the location of the strip in the mill. There is evidence that off-center rolling produces greater loads on one end of both the work rolls and the backup rolls. With steel tandem mill rolls, the load appears to be heavier at the edge of the rolls that the strip is closer to. Spalls have been found on this edge and no spalls on the opposite edge where the distance from the end of the roll to the pass line is greater.

Some photo-elastic work has been done on the distribution of stresses between work rolls and backup rolls. This work shows the very definite effect of moving the strip off center, on stress concentration. Figure 37 shows a simulated 4-high mill with the strip centrally located. The stress concentration between the work rolls and backup rolls is located outside the edges of the rolling path. Figure 38 shows the effect of moving the strip to one side. There is a marked increase in stress concentration between the work rolls and backup rolls on their ends toward which the strip is moved.

The work done at Syracuse University included temperature distribution curves for rolls some time after they were taken out of the mill. One way to evaluate the actual temperature in the mill would be to measure the temperature several times as a roll is cooling, measuring the time from when the rolling of the last coil is completed. By extrapolating back to zero time, an estimate of the actual temperature distribution that existed during rolling could be made.

A measure of the actual roll temperature where it makes contact with the hot strip would be very valuable information.

A more uniform and accurate record system would be very helpful to both the roll users and roll makers to determine the causes of failures and to give information that would be helpful in producing rolls with greater resistance to spalling.

Dr. George Sachs: When one speaks of normal

reduction with a resulting roll separating force of so many tons per in. of strip width, one probably should amend it to say the common or usual reduction and that the roll should be removed for dressing after a specific tonnage has been rolled. However, when excessive reductions are taken for a prolonged period of time, the roll should be removed for dressing long before the normal tonnage is rolled to avoid damage.

The problem of measuring the roll surface temperature during rolling is an extremely difficult one. We have not had any success except in an area where the flash of heat input has already been distributed to the cooling water and the roll body. Some old tests on drawing have shown, even with cold drawing, that surface temperatures in the order of several thousand degrees exist as a flash temperature. How can one analyze the problem. Measurements using tricky thermocouple arrangements, using the cooled body as one leg, show there are tremendous temperatures in very small areas which develop the minute there is friction. Of what significance the very high flash temperature is to roll spalling, I do not know.

James V. Latorre: The measuring of roll surface temperatures is an area which needs considerably more work, especially as it may be related to the development of fire cracking and other surface defects. Temperatures of rolls have been taken several times as the rolls cooled and were plotted to extrapolate back to in-the-mill temperatures. However, it was found that this extrapolation only gives an average temperature of the roll surface practically identical to that measured within 5 to 15 min after shutdown. The work done by Stelco with thermocouples substantiates this statement. In fact, their tests suggest that even for a roll rotation of approximately 120 degrees, not only has evidence of the high flash temperature disappeared but the surface was cooled to temperatures very close to what one is able to measure soon after shutdown. Surface temperatures between slabs actually flashed down very close to the cooling water temperatures. It would be difficult to convince a mill operator that a hole should be drilled in one of his work rolls to permit the insertion of a thermocouple to measure surface temperature. On the other hand, it is difficult to sell a proposal including the cost of the instrumentation necessary to measure these temperatures in the laboratory.

The only cold mill stand in which any appreciable wear was measured was in the first stand. The first stand used cold water as a coolant or lubricant while the other four stands used a warm palm oil and water emulsion. The first thought is that the difference in wear may be directly related to the differences in the lubricating properties of the lubricants.

M. L. Sherwood: The occurrence of deep depressions in the first stand of the narrow mill raises some interesting questions. As noted, a similar condition has been observed on the 56-in. mill at The Steel Co. of Canada, Limited. It developed mainly on the bottom roll of stand 3 at a time when straight bottom rolls were used in combination with concave top rolls, a practice which has been discontinued. Since the work rolls in stands 1 and 2 of this mill do not appear to wear appreciably, it was believed that this type of wear pattern in stand 3 was caused by the bar being nonsymmetrical about its transverse horizontal axis as it left stand 2. It was corrected by dividing the cambers equally between top and bottom rolls. Is it possible that the condition shown for stand 1 of the 44-in. mill results from a negative crown supplied by the rougher?

It has been shown that the backup rolls in stands 3 to 6 of the 56-in. mill wear more near the center than at the ends. If this greater center wear were caused by greater pressure, would it not also occur in stands 1 and 2, where it has been shown that during mill operation the work rolls in these stands have the least concavity? Another hypothesis is that the work roll wear patterns in stands 3 to 6 result in differences in distance from the axis of rotation to the roll periphery, and therefore, differences in peripheral speed along the roll length. Since the backup rolls are driven by the work rolls, there must be a point or area of no slip between them, which with straight rolls, could be expected to extend over most of the roll length. When the work roll becomes worn in the center, the peripheral speed may change, with slip occurring near the center and the no-slip areas moving toward the roll ends. For the frictional forces to be at equilibrium as this occurs, the frictional forces near the roll center in one direction must be balanced by equal and opposite forces in the other direction on the other side of the no-slip points, that is, near the roll ends. The difference in speed between the no-slip point and any other point along the roll length varies directly with the difference in radial distance from the axis of rotation to the roll periphery. As the work roll wear increases, the no-slip points could be expected to move closer to the roll ends, the speed differences becoming larger for the center portions relative to the ends. A greater speed difference at the center could possibly account for the concave backup roll wear profiles which have been observed.

James V. Latorre: Dr. Sachs and I have discussed the probable causes of the depressions at the edges of the roll wear patterns and it is felt that any of several conditions may be contributing. These could be strip with thick or cold edges which would cause higher pressures, strip with transverse camber which is being flattened and fretting at the edges and there may be some effect of the high momentary temperature difference at the adjacent surfaces that are chilled on one side by the cooling water and heated on the other by hot strip. Distributing the roll crown from one roll to the other would seem a likely cause for transverse camber of the strip. A rougher, producing a slab with thick edges or camber, could conceivably cause the condition observed in the 44-in. mill.

There is full agreement that factors other than pressure may have a greater bearing on center wear in stands 3 to 6. However, the relationship between the radial wear at both the center and the edges of the backup rolls vs mileage, shown in Figures 27 and 28 does resemble, by coincidence or otherwise the relationship of load (Figure 36) particularly for stands 3 to 6 with the order of magnitudes of both wear and load between stands 3 and 6 something like 2.5 to 1. However, the wear pattern and magnitude in stands 1 and 2 for both work and backup rolls do not conform for some reason. The theory of a relatively larger slip at the center than at the edges being responsible for greater center wear surely does sound logical, at least it may be a large factor contributing to center wear. ▲

The Influence of Capital on Productivity

by WILLIAM T. HOGAN, S.J.

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. . . . usage of present statistical productivity figures within the framework of their limitations indicates that factors other than man-hours must be considered in establishing a realistic measurement which is in keeping with the technological advances of recent times . . . .

ON September 6, President Kennedy sent a letter to the twelve major steel companies on the subject of prices. After expressing the hope that prices would not be increased, he said: "If the industry were now to forego a price increase, it would enter collective bargaining negotiations next spring with a record of three and a half years of price stability. It would clearly then be the turn of the labor representatives to limit wage demands to a level consistent with continued price stability." A few days later in a letter to David J. McDonald, President of United Steelworkers of America, President Kennedy also voiced the hope that the labor settlement next year would be "within the limits of advances in productivity and price stability."

Thus it would seem that a policy is being suggested that would keep wage increases within the limit of increasing productivity. Presumably, this would make it possible for a company to maintain prices and still absorb wage increases without injuring its profit position.

These developments raise some very serious questions about productivity, one of the most important subjects in our economy today. It is vital not only to prices, wages and profits, but also to our standard of living and our ability to compete with other nations of the world. In spite of its significance, there is, unfortunately, a certain amount of confusion and disagreement about the concept of productivity itself and its measurement.

Productivity is one of the most significant words in economic and industrial vocabulary today. Yet, despite its broad use, it is a relatively new term. Scarcely found in the literature of the 1920's, it began to appear more frequently during the late 1930's and in the post World War II period has become a by-word for economists, statisticians and those engaged in collective bargaining. Some have even advanced increasing productivity as the panacea for our economic ills.

In the years immediately after World War II much was written about productivity. One could scarcely pick up a periodical on economics without seeing an article on the subject. There was much discussion of its various aspects including the means of measurement. This has continued to the present and is of practical significance since productivity is not merely an academic subject, but one which has a focal position in business and industrial life and now may well be put to more extensive use as a wage determinant in collective bargaining agreements.

Thus productivity and productivity measurements are going to play an increasingly significant role in our economic life. Therefore, it is imperative that the concept of productivity, as well as its measurement, be as clear and accurate as it is possible to make them so that current disagreements be resolved and confusion clarified.

Productivity is basically and fundamentally a ratio or relationship between the input factors in production and the resultant output or product and thus is a means of expressing efficiency.

The input factors in any manufacturing operation can be reduced to three general categories, namely, manpower materials and machines. Under the heading of manpower must be included all of the human effort, mental and physical, that goes into production. Thus the hours of management, as well as those of the wage earner, should be considered for they are all vital to the productive process. In the category of materials, all goods and services that enter into the production of the final product are included. In a basic industry, such as steel, one speaks of raw materials such as iron ore, coal and limestone. To these, others must be added which are not raw materials since they have been processed in some way or other. These include scrap, alloys, brick for furnace linings, electricity to operate the mills and furnaces, and a host of others.

The basic raw materials are found in nature and it is, in a sense, good fortune which dictates whether or not a company has an ore body with a high iron content or a low one. In recent years, however, both iron ore and coal have been beneficiated to improve their quality, but this requires the use of capital equipment and thus they are no longer unprocessed materials.

In manufacturing industries such as automobiles, appliances, containers, etc., the materials are seldom raw materials, but finished products of suppliers. These have been constantly improved and developed, so that they become a casual factor in increasing productivity.

The third category of input factors, viz., machinery and equipment, is of great importance for it is the principal means by which production has been increased in quantity and improved in quality during the past half

century or more. The advance in technology, particularly since the close of World War I, has enabled us to increase industrial output tremendously with but a small increase in the labor force of production workers. In fact, the figures of the Bureau of Labor Statistics show an employment of 26,000,000 in all manufacturing industries as of 1919, and only 27,000,000 in 1955, a year which witnessed production records in many industries.

Thus there are three input factors in any manufacturing operation, viz., manpower, materials and machines, yet in spite of this the accepted measure expresses the changes in only one of these factors, namely, manpower. Increasing or decreasing productivity has been calculated in terms of output per man-hour, or conversely, man-hours per unit of output, e.g., man-hours per ton in the steel industry.

The question has been asked repeatedly, why are the other two input factors not included in some way in the measurement since an over-all improvement in productivity should mean greater efficiency in the application of materials and machines, as well as manpower? Further, the expression of productivity only in terms of man-hours per unit of output can be deceiving to the uninformed person and frustrating for those who deal with the figures.

The measurement has many shortcomings so that at best, it is inadequate, and at worst, misleading. If it does not take into account materials and machines, one can only evaluate their productive efficiency indirectly in terms of their effect on man-hour output. This can be grossly misleading at times for it is quite possible that the investment in a new piece of equipment may double man-hour output, yet the equipment may cost much more than twice its predecessor in terms of constant dollars. Thus labor productivity would increase, but in this case capital productivity could actually decline. It is quite possible that an over-all measure of productivity which would include capital might result in a long term trend for the nation, as well as particular industries and companies, that is considerably lower than the man-hour output figures which are used at present.

What has been said of capital equipment can be said equally of materials for here a considerable investment has been made to improve their quality over the years.

Confronted with these factors one may ask, why manpower or labor has been used exclusively as a measure of productivity? The principal answer to the question can be found in the fact that many productivity studies involve the economy as a whole, and here the labor factor is much more significant than it is in a particular industry. Individual industries invest capital in equipment whose cost contains a considerable amount of labor, and the equipment builders in turn buy other capital goods which contain more labor, etc. Thus, when the entire economy is under consideration, man-hour output is a highly significant figure. On the other hand, when one is concerned with the productivity of an individual industry, the situation is different because the purchase of plant and equipment by a particular industry represents capital costs.

Ewan Clague summed up the case for man-hour figures when he said: "We center attention upon labor because, for the economy as a whole, it is by far the largest input . . . comprising as much as four fifths of the total cost of production" ("Social and Economic Aspects of Automation," by Ewan Clague, a talk before the Joint Automatic Control Conference, University of Colorado, Boulder, Colorado, June 28, 1961, p. 6.) The use of man-hour figures for individual industries has often been defended on the ground that they are available and that these data are much more homogeneous and more easily handled than data on capital investment. In response to this, one might note that the only homogeneous factor in man-hours is the hour for the quality of labor, both mental and physical, differs widely.

A further argument in favor of manpower statistics maintains that although crude, they provided a start and a start was necessary.

It must be said in defense of this measurement and the serious statisticians who provided it, that the figures were properly qualified and their limitations set forth. An example of this can be found in a publication by the U. S. Department of Labor, Bureau of Labor Statistics, published in September, 1956, entitled "Man-hours Per Unit of Output in the Basic Steel Industries 1939–55." This booklet presents statistics on man-hour output in the steel industry. However, it devotes more than 15 pages to an explanation of the concept used, its limitations, as well as the technological developments in the industry that helped make the productivity trend possible. Unfortunately, however, when the figures were put to practical use, the qualifications were dropped and the data were used as if exact. This practice, it should be noted, is not confined to productivity data alone, but often applied to other forms of statistics in use today.

The shortcomings of the present productivity measurement have been widely recognized, nevertheless it is the only measurement available and since more stress has been put on productivity, it will continue to be used unless a replacement is developed which will represent the realities of the economic situation more closely.

In order to achieve this objective and produce a measure which reveals the increase in productivity or efficiency of all three factors in the manufacturing process, rather than just that of manpower, an index combining all the input factors must be developed.

From indications in a recent study it would seem that a combined measurement would provide a lower growth rate in productivity over an extended period of time. From statistics which cover a period of almost 70 years, i.e., 1889 to 1957, the following conclusions were drawn:

"Physical output per man-hour in the private economy has grown at an average rate that appears to be about 2.4 per cent per annum.

Comparing output with a measure of labor input in which a highly paid man-hour of work counts for proportionately more than a low-wage man-hour yields a measure of productivity for the private economy that grew at a significantly smaller rate—about 2.0 per cent per annum.

A measure of productivity for the private economy that compares output not only with labor input (determined as before) but also with tangible capital,

each weighted by the market value of its services, grew still less rapidly—about 1.7 per cent per annum.

All these indexes of productivity in the private economy rose somewhat more rapidly than the corresponding indexes for the economy as a whole, including government, when the usual measurements of government output and input are utilized. For the total including government, productivity rose about 1.5 per cent per annum." (From the introduction to "Productivity Trends in the United States" by John W. Kendrick, p. xxxix. The introduction was written by Solomon Fabricant.)

Thus one can see that the failure to include capital and other resources has resulted in an exaggerated trend in the productivity increase.

The development of an index which includes all the input factors presents some difficulties, but they are not necessarily insurmountable. To begin with, the three input categories have no common denominator which can be expressed in terms of physical units. Therefore, they must be measured in terms of value. Thus, materials, manpower and machines must be converted into dollars and related to the output or product, also measured in terms of dollars. To allow for the fluctuations in dollar values over a period of time, a suitable index could be applied so that the dollar values are constant. This type of measurement would afford an opportunity to consider all the materials and services, as well as the capital used in a manufacturing operation. At present, these factors are not included at all, and this is a serious deficiency.

The contribution of manpower, both management and labor, to increasing productivity is not to be lost sight of for decisions to install new equipment, as well as increased skills that are necessary in some instances to operate it, are essential to advances in productivity.

In the analysis of the contribution of capital or machines, two factors must be evaluated: (1) the total amount invested in facilities which represents the capital requirement necessary to purchase the machinery without which productivity increases would be impossible; and (2) the annual contribution of capital to the productive process.

In the first part of the analysis, viz., the total investment in facilities provides an opportunity to examine the major cause for increased productivity. Here is involved a matter of cause and effect. The man-hour output figures are a measurement and simply state the effect which over a long period of time has been favorable since man-hour output has been on the rise. However, it is necessary that there is some idea of why this is so. Thus an analysis of the causes is a requisite to a complete understanding of the effect. The primary cause is capital investment. A few examples will illustrate the point:

1. In the steel industry a primary rolling mill which takes a basic ingot and rolls it down into a semi-finished product such as a slab or bloom was recently replaced at a cost of approximately $51,000,000. The crew on the new mill was virtually the same as that on the previous mill which rolled steel at a rate of 1500 tons per turn. The output of the new facility was virtually double that of the old one so that man-hour output was also doubled. On the surface it would appear that productivity had been doubled, if one used

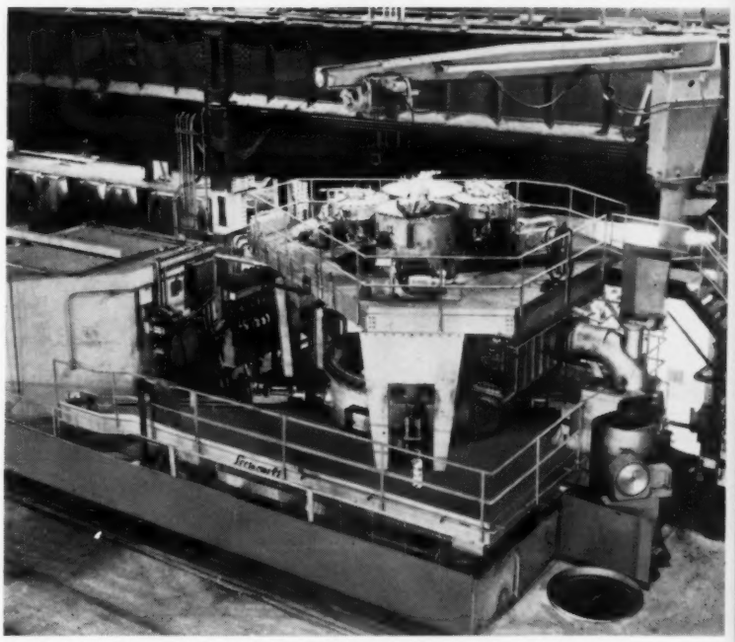

Figure 1 — Large capital expenditures, for the purchase of new equipments, are necessary to permit a steel company to meet the demand for higher quality steels.

man-hour output as our criteria. However, when one considers that the investment of $51,000,000 in the new mill replaced a mill which had been originally installed in 1912 at a cost of $2,000,000, it is obvious that the amount of capital involved even if one makes corrections for the purchasing power of the dollar, is much greater than that which was invested in 1912. An estimate based on construction indices would indicate that the present mill in terms of 1912 dollars could have been installed for approximately $15,000,000. This is seven times the amount invested in 1912, whereas man-hour output on the mill has only been doubled. It is true that the 1961 mill is far superior to its 1912 counterpart, nevertheless, it produces only twice as much and its cost was approximately seven times that of the original mill.

2. A new blast furnace was recently installed at a cost of $24,000,000 with a capacity to produce 2200 tons a day. This replaced facilities which were originally built (but had since been rebuilt a number of times) in 1909 at a cost of $3,600,000. The older facilities produced 1000 tons a day with approximately the same crew as its replacement. Thus, there was an increase in man-hour output of over 100 per cent. However, the amount of capital invested, namely, $24,000,000 would be roughly $7,000,000 in terms of 1909 dollars and thus about twice the investment required for the old facilities. Here there is some parity for an investment of twice as much money increased man-hour output two fold in contrast to the first example where the investment was much greater than the increment in man-hour output.

3. A cold reduction mill has just been installed at a cost of $35,000,000. This replaced two older mills which were built in 1936 at a total cost of $6,500,000 and reduced the labor cost by approximately 50 per cent. If corrected for inflation, the $35,000,000 investment in 1960 would be equivalent to $16,000,000 in 1936. However, the two replaced mills were installed at a cost of $6,500,000; thus a 100-per cent increase in productivity

was achieved through an investment which was approximately 2½ times the original cost.

One can see from an analysis of the capital investment required to increase man-hour output that in two cases out of three, the investment was much greater proportionately than the increase in labor productivity which it caused.

In considering the second point, namely, the annual contribution of capital to the productive process, it is necessary to attempt to evaluate how much of the investment in plant and equipment is consumed each year in the productive process. Obviously, one cannot include the total cost of investment in each year's operation. Although the job could not be done without the use of the entire plant and equipment, only a portion of it is consumed each year. Thus a dollar figure representing the annual consumption of capital would seem to represent its contribution.

At first sight, it may seem that this figure can be easily determined for it represents nothing more than depreciation charges. However, there are two difficult problems that must be solved before one can make a judgment on adequate depreciation costs.

First, there is the question of inflation. It is known that facilities installed 20 years ago should be evaluated at twice the original cost if they are to maintain their value in constant dollars. Thus it would be necessary to revalue total plant and equipment every year on the basis of a price index in order to determine just how much cost should be written off as wear and tear on capital facilities. Otherwise, if the judgment is made on the basis of original cost, the amount of capital contribution to productivity would be grossly understated.

Secondly, there is the matter of obsolescence. This often requires a shorter life for facilities than is allowed under the Federal Tax laws. It is true that the physical life of some machines may be 20 years more, however, at the end of a much shorter period, new developments can render them economically obsolete. This is a pressing problem and will become more so, particularly in view of the amount of funds appropriated for research and development which should speed the rate of technological progress so that the rate of obsolescence would tend to be accelerated. Any measure of capital input which does not take obsolescence into account is deficient and will understate capital's contribution.

The difficulty here is considerable but may be overcome by permitting a more rapid write-off of capital equipment as the Bureau of Internal Revenue has recently allowed the textile industry to do.

A complete index which represents the three input factors must be developed because of the increased emphasis to be placed on productivity in determining wages. If, as has been indicated by the Kendrick study, the inclusion of capital reduces the over-all rate of productivity gains, this should be made clear particularly if the index is to be used for practical purposes. It should also be noted that the inclusion of capital in the productivity index, in some instances, might show a greater growth than man-hour output taken alone. Further, such an index should be on an industry level because bargaining will most probably be conducted on the basis of industry productivity, and it will be of little practical use to talk in terms of national averages. The steelworkers, for example, have in the past few years based their discussions on steel industry productivity.

To be certain that the capital factor and materials are considered in productivity measurements, two alternatives are possible: first, three indices could be constructed, one for manpower, one for capital equipment and one for materials and services. In an industry, such as steel, each of these could be related to physical output, i.e., tons produced, or to the value of output, i.e., sales. Thus, in addition to man-hours per ton one would have dollars of capital consumed per ton and dollars worth of materials and services consumed per ton. This would give some direct idea of the efficiency of capital in place of the present indirect measure.

The three indices should not be too cumbersome to handle and could present relatively accurate data in each instance. It would then be possible to balance the three and thus establish an indication of productivity growth which would be much closer to reality than the present single figure. Furthermore, manpower could be measured in dollars rather than hours and this would help to some degree to correct the difference in the relative value of labor input, for presumably the higher paid man is paid more precisely because his hour of work is a greater contribution.

Second, if in place of the three indices, one is desired which would include all three input factors, such an index could be constructed which would represent total efficiency and productivity by reducing the three input factors to a common denominator, viz., constant dollars. This figure would be related to output stated in terms of value, and it would seem that in establishing such an index, sales, again expressed in constant dollars, would be the only feasible figure. Admittedly, there are difficulties here for sales prices are very often affected by extraneous factors. However, in an industry such as steel where the products manufactured by each company are similar, and in some cases almost identical, competition demands that they be sold for the same price. No purchasing agent will pay more than necessary for steel which will meet his specifications unless, of course, one is in an extreme sellers market. Thus, no matter what external factors are present, the price will almost always be the same for similar products sold throughout the industry. Therefore, the difference between the cost of input factors and sales expressed as a percentage return on sales would indicate the relative efficiency or productivity trends in the companies within the industry.

An individual company could use the same method or possibly compare its input factors with an internal standard of performance correcting for any change in dollar value over a period of time.

The index suggested here bears some resemblance to a profit and loss statement corrected for fluctuations in the value of the dollar. Its development involves a number of difficulties, particularly that of estimating a relatively exact figure for capital input. Nevertheless, it serves the function, as does the triple index, of taking capital and materials into account and thus presents a much more realistic measurement of complete productivity than is available at present. ▲

Elimination Of A Coke Plant Relief Holder

by H. E. TAYLOR,* Superintendent,
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. . . . a control scheme to regulate gas pressure in a coke plant system must be carefully engineered and designed, but it must also be properly maintained if it is to continue to function as originally intended . . . .

BEFORE the gas contract with a local utility expired in 1954, all send out gas was handled by three boosters at 4-psi discharge pressure (one electrically driven, 24,000,000 cu ft per day; and two steam driven, 16,000,000 cu ft per day). The level in the 40-year old relief holder was controlled by the by-product engineer, with the aid of a cable and ball indicator arrangement on the inner wall of the building, requiring him to speed up or slow down the booster to maintain a safe working level of the holder.

When the gas contract expired, in December, 1954, four reciprocating horizontal-duplex, 4-stage, electrically-driven gas compressors with 22-psi discharge were installed at the extreme opposite end of the by-product building to send high-pressure gas to the steel plant on the opposite side of the river, at which time an automatic control system was installed at the steel plant to take care of the increased volume. The steam-driven boosters were left intact in order to take care of any emergency if necessary to go back on low-pressure gas. At that time pressure was controlled in two ways:

1. By means of a pressure relief valve, connected to the bleeder on the high-pressure side, this valve is set at 23 psi.
2. By position of the relief holder.

Eight limit switches were spaced one ft apart along the vertical movement of the holder and were activated as the holder would rise or fall to load or unload the compressors by stages; thus controlling the amount of gas pumped.

The holder was condemned in 1958 and Alan Wood Steel Co. was faced with the problem of building a complete new holder. In addition, further problems would be having to locate a new holder at a point approximately 1500 ft from the present site completely out of view of the by-product operating personnel, installing considerable additional piping and maintaining operations with the condemned unit during the construction period. Therefore, it was natural to investigate the possibility of complete automation of the operation as an alternate. Further engineering evaluation brought out the fact that a new holder at the present location (not considering the remote location) would cost considerably more than the automatic control system.

Figure 1 is a layout of the present gas system. Figure 2 shows the reciprocating high-pressure compressors. Figure 3 shows the relief holder, which is obsolete. The limit switches at different points on the holder which were used to control the reciprocating compressors can be noted. Figure 4 shows the general layout of the exhausters and boosters.

In considering automatic control equipment, it was felt that it was essential to meet the following requirements:

1. Maintain gas inlet pressure to the compressors or boosters at a pressure of 14-in. water column. This is required to assure proper operation of the by-product plant and underfiring of the ovens and the coke plant boilers which on occasions use gas as fuel.
2. Provide an automatic system which would follow the existing operational sequence in loading and unloading the compressors.
3. Incorporate an arrangement to provide constant-pressure control when on emergency operation through the steam turbine driven boosters.

* Deceased.

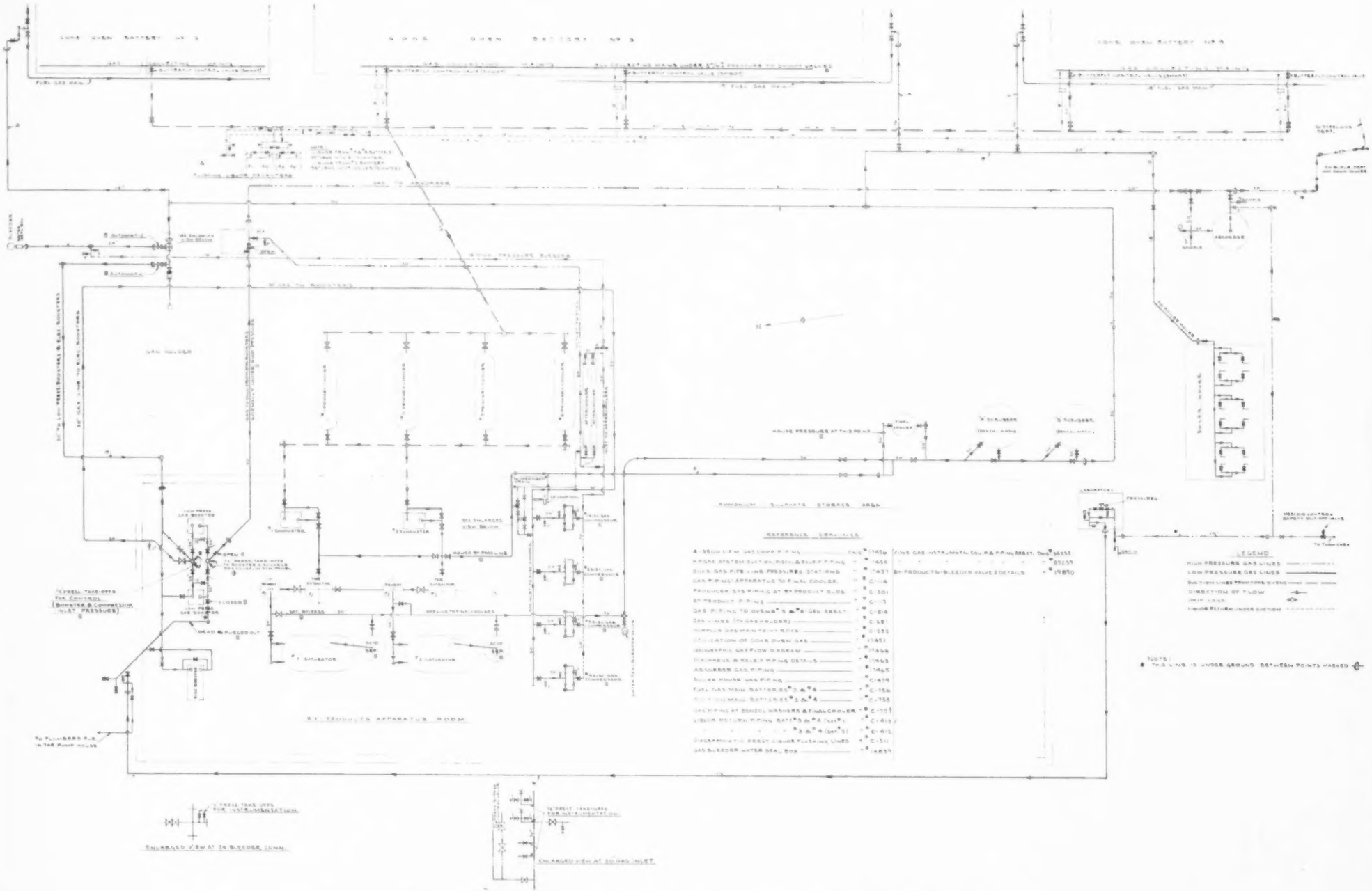


Figure 1 — The present system has functioned very well since its installation.

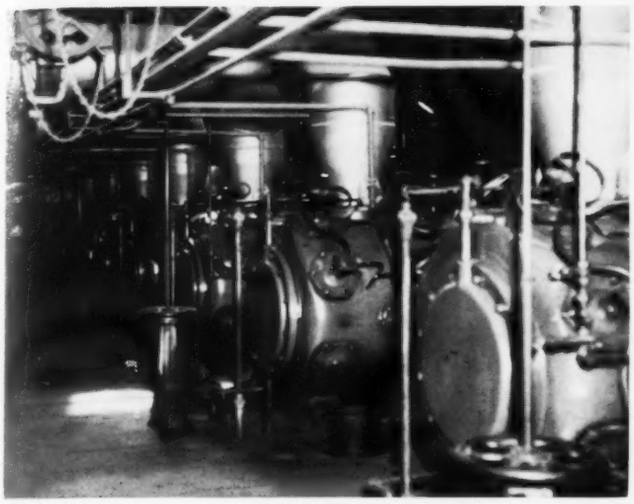


Figure 2 — Four reciprocating horizontal-duplex, 4-stage compressors are used to compress the gas to 22 psi.

4. Provide automatic protection for low or high gas pressures.
5. Provide a reliability factor equal to or greater than that to which was available with the conventional holder installation.
6. Accomplish the changeover without any shutdown.

In the automatically-controlled system the pressure in the main after the scrubbers is held at 14-in. water column. The gas pressure to the steel plant is 22 psi maximum. Three reciprocating compressors have sufficient capacity to handle the gas flow with one as a spare. There are eight air-operated unloading valves on each compressor. As the flow increases or decreases, combinations of unloading valves are actuated. An electrical interlock system determines the unloading valves to be actuated.

Figure 5 is a simplified block diagram of the pneumatic control system and the electrical interlock system.

A more detailed diagram of this system is shown in Figure 6. The control system itself is of the pneumatic type. Dual-pressure control systems are installed. Gas pressure is regulated by duplicate by-pass valves around the compressors. Only one system is used at any one time, as well as its representative by-pass valve. Two points of pressure measurement are installed with one being utilized and one point as a spare. For the purpose of explanation, it is assumed that pressure control system No. 1 is placed in operation.

A system selector valve (RS-4) actuates a 3-way switching valve (TV-26) to receive the pneumatic control signal from No. 1 pressure controller and block any signal from No 2 pressure controller. The next step is to place No. 1 by-pass valve on automatic operation. This is done by actuating transfer valve (RS-2) which, in turn, actuates a 3-way switching valve (TV-24) for proper transfer of the control signals. The signal from the switching valve (RS-2) also actuates the signal lights on the control panel by a pressure switch (PS-51) which indicates whether the system is on automatic or manual control. The pneumatic-control signal from valve (TV-24) is transmitted to a 3-way transfer valve (TV-27) and when on normal

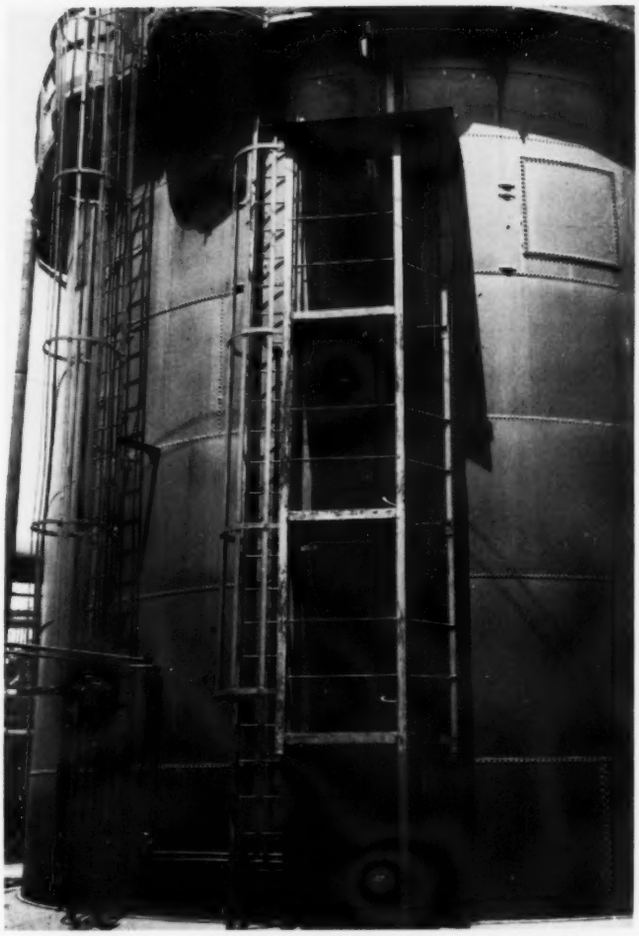
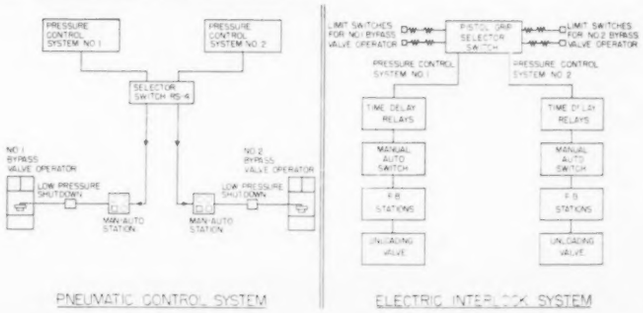


Figure 3 — Eight limit switches spaced along the side of the holder loaded and unloaded the compressors as necessary.

Figure 4 — Steam turbine driven boosters are used for emergency operation.

Figure 5 — The system is pneumatically controlled with an electrical interlock scheme.



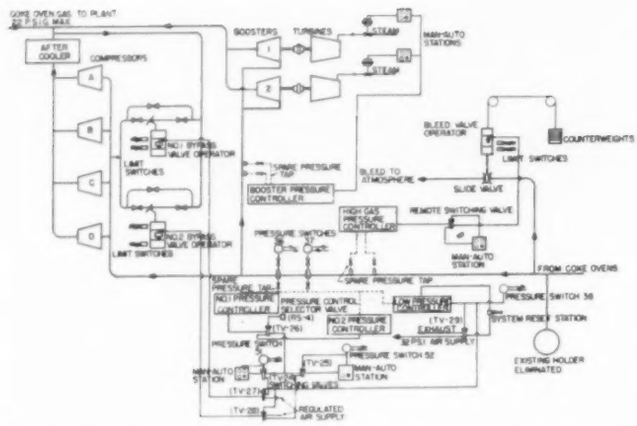


Figure 6 — A detailed schematic of the control system is illustrated.

operation will transmit the same signal to No. 1 by-pass valve operator. However, the electrical interlock system must also be placed in the same sequence as pressure switch (PS-51) which is tied into the interlock system. Unless the circuit is cleared in the proper sequence No. 1 pressure control will not go into operation. After the circuit is cleared and the No. 1 pressure controller is on automatic operation, any deviation in gas pressure from that to which the controller is adjusted will cause the pressure controller to transmit an error signal to No. 1 by-pass valve operator and position the valve as required.

The results obtained are shown in Figure 7 which is a reproduction of charts for a normal day of operation. Inlet gas main pressure is controlled at about 14-in. water column. The blips are the coke-oven fuel gas reversals. The charts show records of low and high gas flow to the steel plant.

As the main gas boosters are reciprocating compressors, it was necessary to use a by-pass valve for accurate regulation of pressure due to the large variation in volume when an unloading valve is actuated. There is a volume change of 875 cu ft in each step of an unloading valve. The unloading valves are actuated by limit switches on the valve operators. If, for instance, No. 1 by-pass valve is near the open position and the gas pressure tends to rise, a further movement of the valve operator will trip the limit switch which in turn, actuates an unloading valve to handle more gas. If the volume demand change is less than 875 cu ft, the valve operator will move in the direction to close the valve to regulate the pressure. If the volume change is greater than 875 cu ft, a time delay relay will actuate the second unloading valve and this sequence will continue until the by-pass valve is moved into a regulating position. A similar sequence of operation will continue if the gas pressure tends to decrease and the by-pass valve is near the closed position. This operation is handled by an arrangement of relays and stepping switches. As mentioned previously, one compressor is used as a stand-by and to make the situation more complex, compressors A and B always operate in parallel and compressors C and D operate in the same manner. This will permit any compressor to be used as the third compressor, as well as having one as a stand-by.

Each pressure control system has its own series of

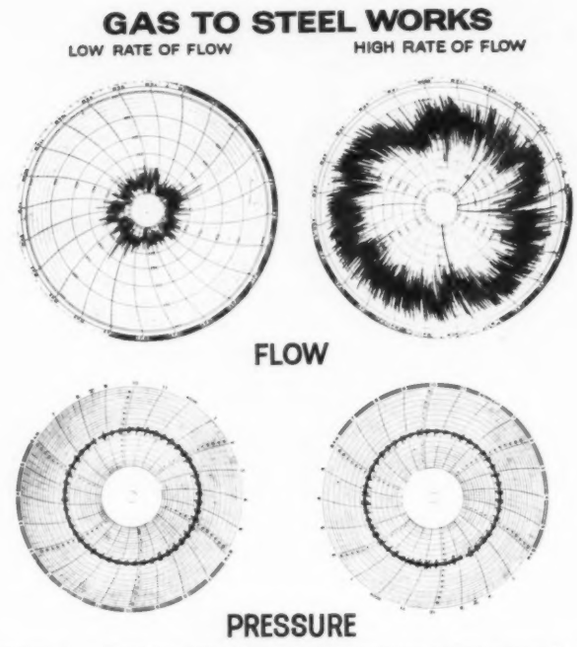


Figure 7 — Typical gas flow and pressure charts are illustrated.

eight lights which indicate the stages in operation. The sequence of operation is best described by referring to Table I. It will be noted that two configurations of operation are shown. One in which compressors A and B are in parallel with compressor D as a stand-by. In the second configuration compressors C and D are in parallel with compressor A as stand-by. Referring to configuration No. 1, when light 1 is on, compressors A and B will have the unloading valves set so that each compressor will handle one fourth of its respective capacity. When light 2 goes on, compressors A, B and C will each handle one fourth of their respective capacity. When light 3 goes on, compressors A and B will each handle one half of their respective capacity while compressor C will still operate at one fourth capacity. When light 4 goes on, each compressor will operate at one half capacity. From here on, the sequence of operation will come in the same order until the full capacity of each compressor is reached. On a decrease in capacity, the operation will be in reverse with compressor C dropping load first.

In the second configuration with compressors C and

Figure 8 — The pneumatic system which controls the unloading and loading of the compressors is illustrated.

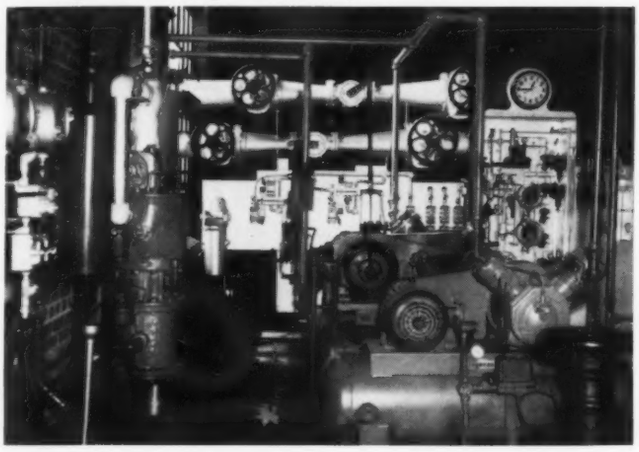


TABLE I

Lights in operation	Compressors in Operation and Capacity							
	Configuration No. 1 with compressors A and B in parallel				Configuration No. 2 with compressors C and D in parallel			
	A	B	C	D	A	B	C	D
8	1	1	1	..	..	1	1	1
7	1	1	3/4	..	..	1	3/4	3/4
6	3/4	3/4	3/4	..	..	3/4	3/4	3/4
5	3/4	3/4	1/2	..	..	3/4	1/2	1/2
4	1/2	1/2	1/2	..	..	1/2	1/2	1/2
3	1/2	1/2	1/4	..	..	1/2	1/4	1/4
2	1/4	1/4	1/4	..	..	1/4	1/4	1/4
1	1/4	1/4	..	..	..	1/4	..	..

D operating in parallel and compressor A as a stand-by, the sequence of operation will begin with compressor B. When light 1 goes on, compressor B will handle one fourth of its capacity. When light 2 goes on, compressors B, C and D each will operate at one fourth capacity. When light 3 goes on, compressor B will operate at one half capacity with compressors C and D operating at one fourth capacity. When light 4 goes on, each compressor will operate at one half capacity. This sequence will follow until compressors B, C and D are operating at full capacity. Upon a decrease in capacity, compressors C and D will drop their load first. Figure 8 shows the by-pass valves and control equipment.

The gas system is also protected for low gas pressure. Referring to Figure 6, a low-pressure gas transmitter measures the main header pressure. When the pressure is above 4-in. water column, the gas pressure transmitter transmits a 30-psi air pressure signal to 3-way valves (TV-27 and TV-28) to keep the ports in the proper sequence to receive the pneumatic signal from the pressure control system which is in operation. The 30-psi signal pressure is also transmitted to a 3-way valve (TV-29). When the gas pressure drops to 4-in. water column or lower, the action of the gas pressure transmitter will actuate the above-mentioned 3-way valves and in turn, close both by-pass valves. The control system can be placed back in operation only by operating the system reset station (RS-5). However, the gas pressure must have risen above 4-in. water column in order to have the system reset station operate to place the control back on either automatic or manual control.

The gas system is also protected against too high a pressure by opening the present bleed valve. The bleed valve was previously mechanically connected to the gas holder. This has been disconnected and a pneumatic cylinder was installed with a counterweight. Referring to Figure 6, a separate gas pressure controller is set for 17-in. water column. When this gas pressure is reached the controller transmits a pneumatic signal to the bleed valve operator and positions the valve as required. An automatic-manual control station (RS-1) permits manual positioning of the bleed valve from the main panel when desired. Figure 9 shows the bleeder valve as modified for automatic control.

Figure 9 — The bleed valve has been converted to pneumatic operation.

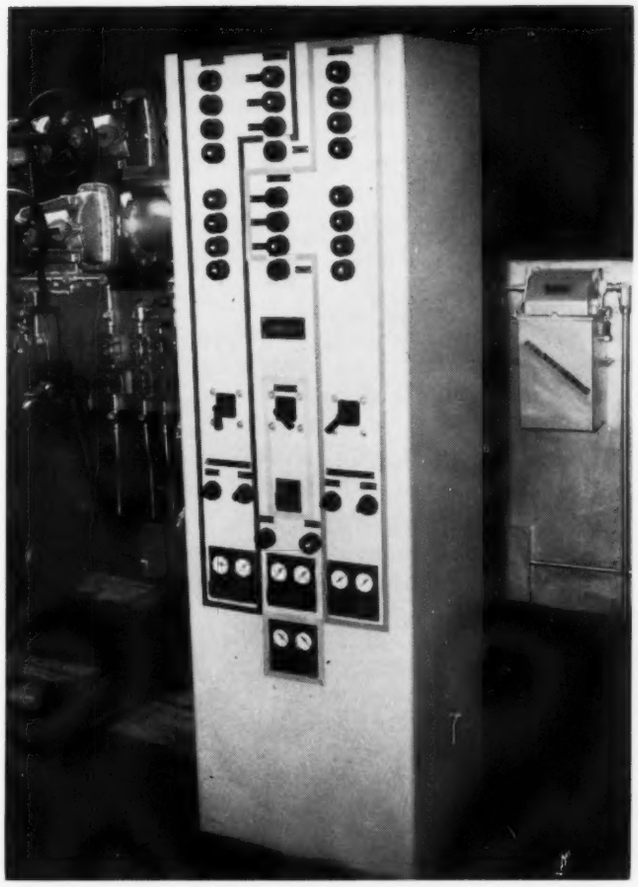


Figure 10 — The control panel is broken down into two distinct sections, one for each of the pressure control systems.

A separate gas pressure control system is installed for the turbine driven boosters. As shown in Figure 6, the pressure controller in this case operates steam valves to control turbine speed. This system is only used as a stand-by.

While the safety interlock system seems quite complicated, it is relatively simple and is obtained by the proper installation of pressure switches. Each function is provided with two duplicate switches. One for operation and the second for maintenance purposes. There are five pairs of switches for the following functions:

1. A signal light and audible alarm when the gas main pressure drops to 6-in. water column.
2. By-pass valves around the compressors close when the gas main pressure drops to 4-in. water column or when the air supply in the control system drops to 32 psi.
3. Complete control system shutdown when gas main pressure drops to 2-in. water column.

4. A signal light and audible alarm if the pressure control selected is not properly synchronized.
5. Double-contact pressure switches in the compressed air supply. When the control air pressure drops to 65 psi, an audible alarm will be given. When the air pressure drops to 45 psi, the air supply will be cut off to the unloading valves on the gas compressors.

At present there are four sources of air supply for the control system as follows:

1. One motor-driven air compressor.
2. One steam-driven air compressor.
3. Five bottles of high-pressure air.
4. The main plant air supply.

Figure 10 shows the control panel. It should be noted that the panel is blocked off in two sections, each section denoting a separate pressure control system. Beginning at the left hand side and the top, there are eight signal lights which comprise the unloading valve sequence operation for pressure control system 1. Directly beneath the signal lights is a pistol grip switch for manual-automatic operation of the unloading valves. Directly beneath the pistol grip switch are two push-button stations for the unloading valves. One push-button station is for increasing stages of operation and the other is for decreasing. The number of stages in operation will be shown by the indicating lights. Below the pushbutton station is an automatic-manual control station of the by-pass valve operator.

Pressure control system 2 is on the extreme right of the panel and the stations are in the same order as for pressure control system 1.

Directly at the top and in the center of the panel is an indicating light, which when lit, shows that pressure control system No. 1 is selected for operation. Directly underneath it is the light to show when the pressure control system is on automatic operation and below this the light to show when on manual operation. These two lights are actuated by the automatic-manual transfer valve on the by-pass valve relay station. The next light below, when lit, indicates that the gas-main header pressure has dropped to 6-in. water column. At the same time, an alarm is sounded. The next three lights indicate control on automatic-manual for pressure control system 2. The bottom light in this group indicates a complete shutdown of the system when the gas pressure in the main header drops to 4-in. water column. The pistol grip switch in the centerline of the panel assigns the electrical stepping switch to the selected pressure control system. This switch and the pistol grip switches on either side must be in proper synchronization for the electrical interlock system. The square handle following is the transfer valve (RS-4) which pneumatically sets up the selected pressure control system. This means that the transfer valve, with the two mentioned pistol grip switches, must be in synchronization before the pressure control system will operate. When synchronized, a light on the side of the panel will go on, indicating "all clear" and the system is ready for operation. If not properly cleared this light will not go on and an alarm is sounded indicating a fault in synchronizing. Next in line are two indicating lights to show whether the slide bleed valve is fully open or closed and below the lights is the manual-automatic station for the slide bleed valve. The last station is the system reset station which must be actuated after a complete plant shutdown.

No unusual difficulties were encountered in adjusting the control system to plant conditions. There is an indication at all times of the setting of either pressure control system whether on manual or automatic, so switching from one pressure control system to the other can easily be made. The by-pass valve operators are furnished with cam bars and these were characterized and the limit switches set so that the handling capacity of the valve at the switching point is greater than the volume change by the step change of the unloading valves on the compressors.

While this system is a departure from present thinking of coke-oven gas pressure control, the results obtained point that this mode of operation is practical and satisfactory. This system has been in operation since March 31, 1960. No attention is required upon the part of the plant operator unless an alarm is sounded. A constructive approach on the part of the plant personnel, together with very close cooperation by the control manufacturer personnel, make such results possible. However, it must be borne in mind that the control system will perform only as well as the rest of the equipment in the plant, which means good housekeeping is a necessity. Alan Wood has a definite schedule for rotation and cleaning of the compressors to assure carefree operation. A similar schedule is maintained for the operation of the control system.

Every thought was given to possible plant failures and the control system was designed to meet such failures. It is not intended that this system will displace present coke plant systems but that it will demonstrate what is possible with careful engineering and design.

Discussion

PRESENTED BY

THOMAS LAW, JR., Fuel Engineer, Charge of Fuel Div., Bethlehem Steel Co., Bethlehem, Pa.

C. E. PRITCHARD, General Superintendent of Mills, Alan Wood Steel Co., Conshohocken, Pa.

GEORGE HEIN, Supervisor, Instrument Dept., Alan Wood Steel Co., Conshohocken, Pa.

Thomas Law, Jr.: Dealing with an over-age condemned holder is a problem which some have already had to face and others who have holders may soon have to cope with, so the subject is very opportune.

The control system which is described in the author's article is the result of considerable planning and appears to be able to cope with almost any eventuality which might arise.

Reliability is one of the foremost factors in guiding the engineering and installation of this type of system. Reliability is always one of the first things which an operator must consider when he is faced with the necessity of having to abandon a holder which has been in service for many years.

Many operators have inherited holders from their predecessors, have gone through many years of operation and have become so accustomed to gas-system operation with a holder that the thought of operating without a holder is alarming.

However, when sufficient thought is given to this problem, one realizes how much money is being spent in maintenance and operation, with a holder, and then when the end of the normal life of the holder is reached there is the necessity of actual replacement. The cost of replacement is of such proportions that one must look for other means of accomplishing pressure regulation.

The author has given a description of a control system that replaces the holder at Alan Wood, and it demonstrates what can be done in installing and engineering a reliable control system which effectively eliminates the holder.

It is true that part of the success of such a control system depends upon a regular schedule of preventive maintenance. Such a program compares favorably with the cost of operating and maintaining a holder.

Bethlehem had to deal with the problem of a condemned and leaking holder almost three years ago. At the same time there was an inadequate supply of coke-oven gas to meet steel plant requirements. Both problems were solved by abandoning and dismantling the holder and installing a control system which permitted the injection of a natural gas-air mixture to supplement the regular supply of coke-oven gas. Coke-oven gas is base loaded and the natural gas takes the swings to satisfy the plant coke-oven gas requirements.

There is one factor which would tell very briefly how effective the control system, which was installed to replace the holder, is; that is, the gas bleed experience. What is the amount of gas bled, compared with what would have been bled if the holder had been in service and in good condition?

C. E. Pritchard: The bleeding of gas has been virtually eliminated since the installation of the new control system. This added benefit is believed to be the result of minimizing the human judgment errors involved in controlling gas volume by means of the holder, for the present system controls both high and low pressure by instrumentation on an automatic cycle.

To handle the plant gas distribution with the steam-driven booster during periods of emergency a priority system has been established complete with a low-pressure alarm and shut-off valves at the various points of consumption. The open hearth is used as a balance wheel to pick up or drop gas volume on an automatic control basis.

Due to the need for coke gas only at the iron powder plant a separate supply line was installed at a point ahead of the feed to the gas mixing station. As an added measure of control a shut-off valve was inserted in this line direct from the main to the iron powder plant which is actuated to shut off in the event the oxygen content develops to a point considered as hazardous to this operation.

Combination burners are provided at the plate mill, soaking pits and strip mill to assist in the most efficient distribution of the gas available. Natural gas and air admixture is also employed within limitations in affecting the fuel balance, the iron powder plant excepted.

Check valves are employed in the lines in order to handle the pressure differential encountered between the natural and coke gas supply. Adequate control of the lower pressure coke gas available during periods of emergency is provided at the gas mixing station.

Member: Explain more in detail how the compressors are loaded and unloaded.

George Hein: The unloading valves on the compressors are regulated by a limit switch which is set to operate on the open and closed end of the reducing valve. If the gas pressure in the main increases or decreases off the set point of 14-in. water column, this causes the by-pass valve to move in the open or closed direction and if not corrected by the increase or decrease in volume through the by-pass valve, it then trips a solenoid valve unloading air pressure from same which in turn puts on or off another stage of the compressor. These are handled by an arrangement of relays and stepping switches. The by-pass valve handles any gas main pressure between 13½ and 14½-in. water column or ½ in. either side of set point. (This control setting is adjustable if necessary.) If valve capacity is not great enough to stabilize pressure at 14-in. water column then the unloading valves come into operation. The system has run for hours with the by-pass valves doing the controlling without bringing on or taking off any additional stages of the compressor.

Member: What would happen if the by-pass valve sticks?

George Hein: The possibility of the by-pass valve sticking is remote, but if it should stick in the open position it would trip the unloading limit switch which unloads the compressors because the pressure in the gas main would change. Should this condition continue to a point where it would shut off all compressors, then the gas main pressure would arise to 18-in. water column causing the bleeder valve to open and 18-in. water column would be held in the gas main instead of the normal 14-in. water column. When the compressors are all shut off, an audible alarm warns the operator of trouble.

If a low-pressure problem is encountered and this condition is not corrected before the gas main pressure reaches 4-in. water column, then the system safety control will close both by-pass valves. In order to operate the system reset station on either manual or automatic control a minimum pressure of 4-in. water column must be maintained. Complete control system shutdown is provided when the gas main pressure drops to 2-in. water column.

Member: Is there any additional maintenance cost with the new system?

George Hein: On the basis of experience to date it is believed that over a period of years the maintenance cost with the new system will be less. During operation of the old system there was a substantial yearly cost for millwrights, painters, etc., which carried over at a lesser degree during the period when the holder was maintained with the new system. With the present system the only men involved are instrument mechanics, who are of a higher caliber and also higher cost per hr, but the amount of time required to maintain the system is much less; also, the gas control system is much better and much safer. ▲

by W. E. SCHWABE, Product and Process Development Laboratory
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fundamentals of Heat Distribution and Refractory Wear in electric steel furnaces

. . . . side wall hot spots are sources of furnace downtime and excess refractory wear. The effect of these hot spots can be reduced by phase rotation and proper electrode regulation. Furthermore, repositioning of the electrodes to decrease the radiant heat density impinging on the side wall in the hot spot area could minimize the problem . . . .

SERVICE life of refractory is a major factor in the economics of steel-melting operations. Because of the high temperatures required for melting and refining the charge and the high rate of Btu input to the furnace, certain areas of the refractory wear out faster than others. This holds true for combustion type and electric furnaces.

This article is an attempt to analyze conditions encountered in electric steel furnaces, where "hot spots" are formed at certain locations on the side wall and roof.

CAUSES OF REFRACTORY HOT SPOTS

Hot spots are caused by the following factors and combinations thereof:

1. Heat radiation from the arcs, especially at the end of meltdown and/or during refining when little or no solid scrap is left to shield the refractory.
2. Mechanical erosion due to forces resulting from arcs and from thermal convection.
3. Chemical reactions between charge or slag vapors and refractory.

The density of radiated arc heat upon the inner surface of the refractory is in all probability the decisive factor in refractory economy. Mechanical erosion due to arc jet effect has been found to be another cause of refractory wear and was demonstrated by J. A. Brosovic in an excellent high-speed motion picture and article.[1]* It can be assumed that this effect, as well as chemical erosion, is also related to temperature, and consequently to heat or arc energy. Therefore, this article is concerned primarily with the distribution of heat energy to the refractory during the most critical periods of a furnace heat (the latter part of meltdown and refining) and the factors causing nonuniform distribution of heat on the inner refractory surface.

CALCULATION OF THE RADIATED HEAT DENSITY PATTERN

Assuming that the three arcs are considered as three point sources of heat radiation located on the corners of an equilateral triangle (Figure 1) circumscribed by a circle of the diameter 2r, the heat density distribution (H) on the side wall with an inside diameter of 2R can be calculated by means of well known laws. These include Lambert's law, which states that radiation density (H) are proportional to the cosine of the angle of incidence, and the law of radiation, which states that density (H) decreases with the square of the distance between the source and the receiving surface. H may be expressed in kw per sq in. or other corresponding units.

* Numbers in parentheses refer to Bibliography at end of article.

Figure 1 represents a schematic cross section of a furnace shell with a refractory diameter of 2R, and three equal arcs, A, B and C located on the corners of an equilateral triangle, circumscribed by a circle of radius r, a customary condition in production furnaces. The refractory circle is divided into 360 degrees, beginning and ending at a point P_1 located opposite arc A slightly above the melt level. If it is assumed that the scrap is melted, and that the arcs can freely radiate upon the side wall, the radiated heat received at point P_1 on the side-wall lining, consists of three components: heat from arc A being most intense because of the short distance (R−r) and 0 angle of incidence; and heat from arcs B and C each being less intense because of the larger distance from the wall, and appreciable angles of incidence. Identical conditions exist at the points located at 120 and 240 degrees. At in-between points, for example P_2, the total of the absorbed heat energy also equals the sum of the components from each arc, each given by distance and angle of incidence. If points further above the slag line or at the roof are to be considered, the problem develops into a 3-dimensional proposition.

Furthermore, it can be stated on the basis of the above-mentioned laws that the heat density (H) at all points, especially on the lower parts of the side wall increases as the ratio r/R increases, that is, as the arcs (and electrodes) are moved toward the side wall in a furnace shell of given diameter.

Other simplifications aiding this calculation include: the assumption that no reflection occurs; the assumption that electrode tips and profiles do not cast shadow patterns on the side wall and roof; and the assumption that the magnitude of radiated power is identical in all three arcs. Furnace operators will agree that these assumptions are questionable in practical operation because slag or melt surfaces do reflect heat, and electrodes, due to their physical dimensions, have a shielding effect. Power unbalance caused by electrical asymmetry can be readily inserted in the calculation: it would require the adjustment of the nominal heat value of each arc in accordance with the electrical power characteristics.

Being aware of the existence of these complications, the distribution of heat density has been calculated according to the above-mentioned laws of radiant heat for a horizontal refractory circle just above the melt level. A refractory side-wall ID of 20 in. and an electrode circle diameter of 5.09 in. were chosen yielding a ratio r/R = 0.258. For simplicity, it was assumed that the heat density (which is not to be confused with temperature) radiated by one arc upon the side-wall increment nearest to the electrode, is unity. This applies, e.g., to point P_1 at the 0-degree location (Figure 1) receiving heat from arc A only. Since the calculation is aimed at the differentials between maxima and minima of H, it is not necessary to use specific units. The results of this calculation are shown in Figure 2.

Curves A, B and C depict values of heat densities of the inner side wall slightly above the melt level, as a result of the radiation of each individual arc. The horizontal axis is the stretched out circle of the side wall calibrated in degrees in accordance with

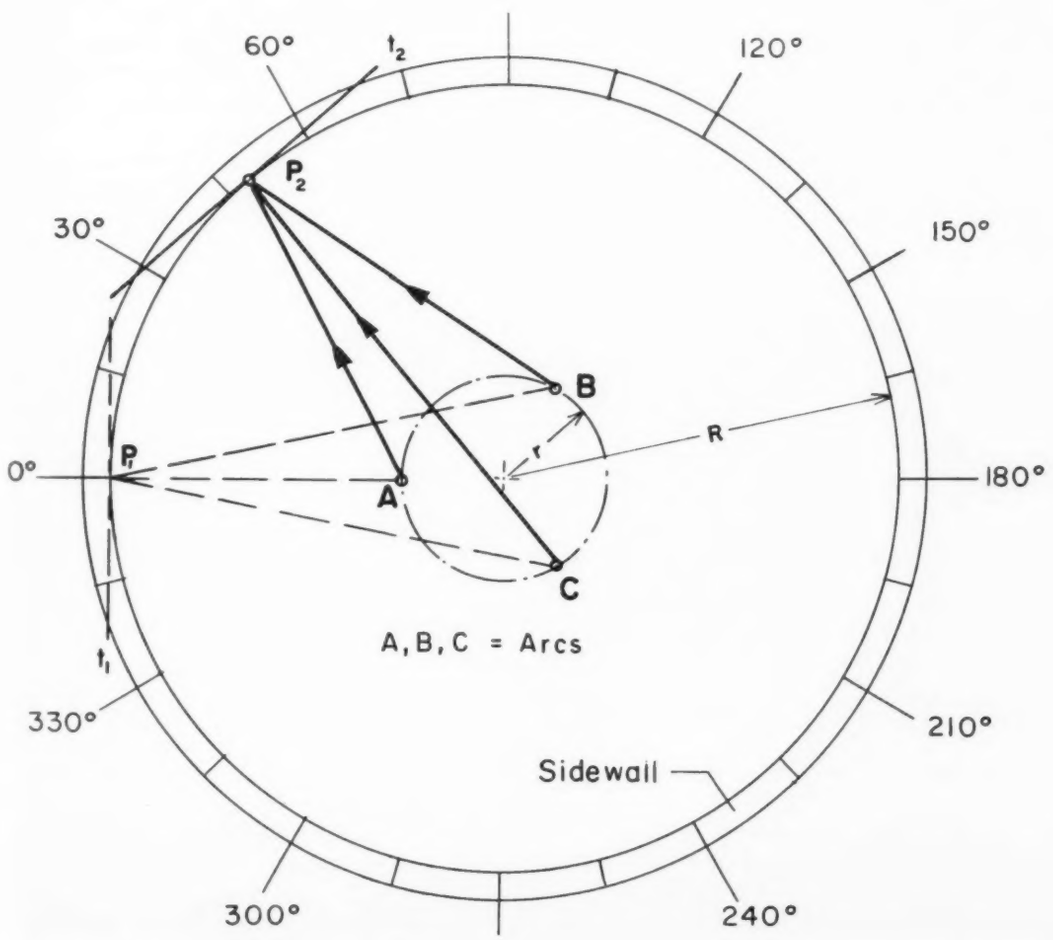


Figure 1 — Schematic representation of the furnace illustrates the nomenclature used.

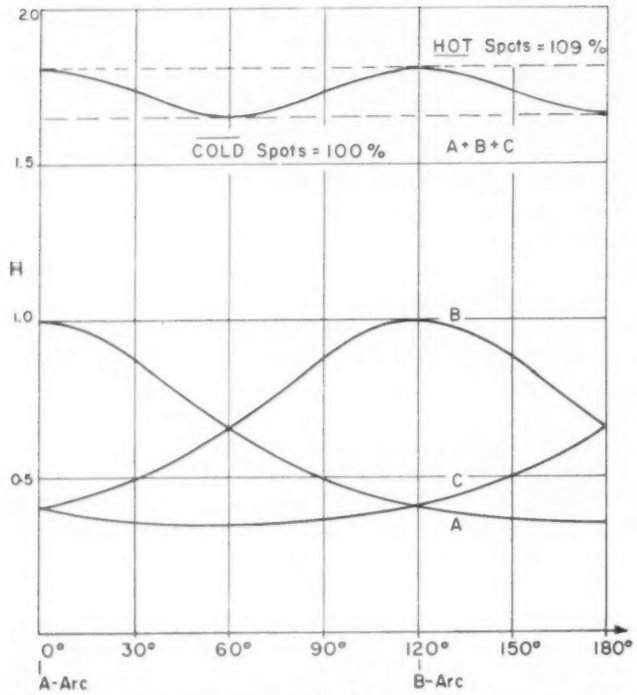


Figure 2 — The heat density (H) is calculated as a function of distance around the furnace wall.

Figure 1. Because of symmetry, only a half circle needs to be shown. It should be repeated that heat density is not identical with temperature; however, the temperature pattern is in qualitative agreement with the heat density pattern. Note the great variation of heat density over the semi-circle resulting from each arc.

The uppermost curve (Figure 2) shows the sum of the individual values of heat density which is representative of the thermal load of the refractory, if the furnace was operated under the assumed simplified conditions. There are maxima (hot spots) of heat density opposite each arc at 0, 120 and 240 degrees of the periphery and minima (cold spots at the halfway mark between electrodes at 60, 180 and 300 degrees).

The differential (d) between maxima and minima is a yardstick for the degree of nonuniformity of heat radiation over the side-wall circle. The differential can be defined as follows:

$$d = \frac{\text{H maxima} - \text{H minima}}{\text{H minima}} \times 100$$

In this case, it amounts to approximately nine per cent. In general, it is governed by the ratio r/R, the ratio between the electrode circle and the refractory circle. A small electrode circle tends to equalize the heat as the arcs move closer to the furnace center. If all three arcs were combined, as in the case of a single-phase furnace, the heat on the side wall would be uniformly distributed.

Conditions for other ratios of r/R can be calculated. Since this ratio on most of the production furnaces does not deviate too much from the value used in this calculation, the above theoretical results are representative for most furnaces under the assumed simplified conditions.

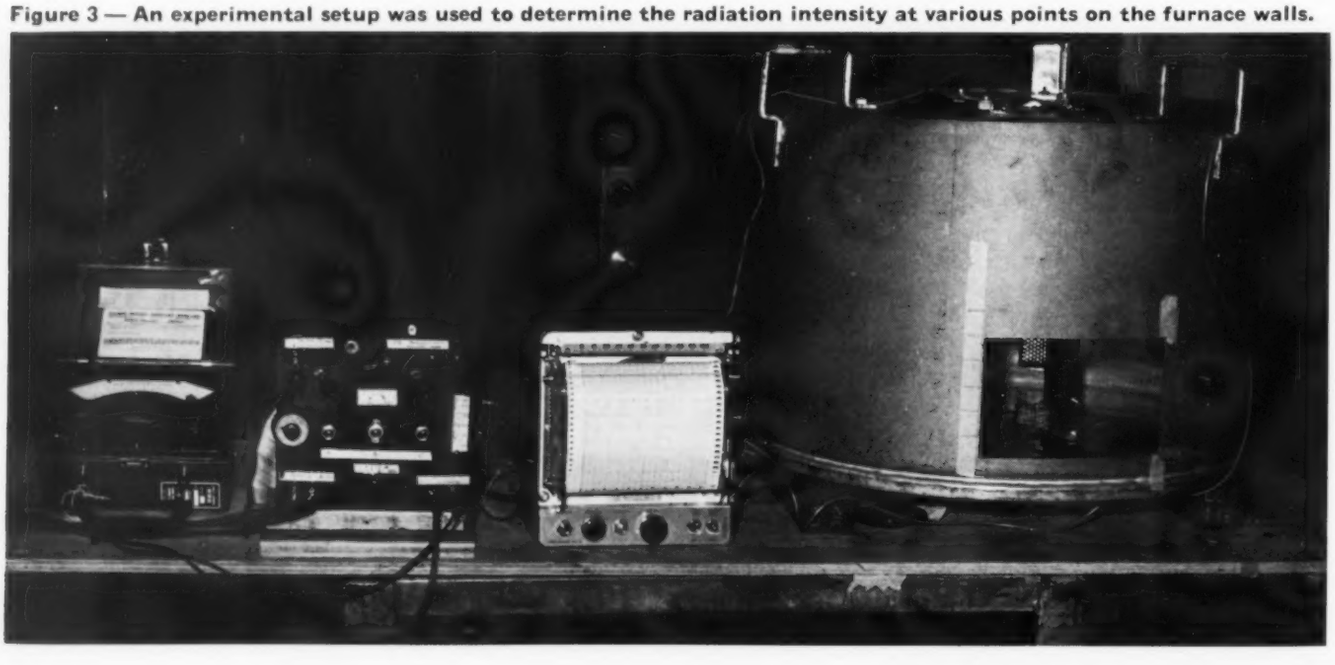
PHOTO-ELECTRIC ANALOG METHOD

The above-described theoretical method applied to the whole inner refractory surface is not only cumbersome but has, as already indicated, certain drawbacks which may lead to erroneous results. In addition to the already mentioned simplification, it is known that the Lambert cosine law applied to refractory surfaces requires certain corrections.[2]

In order to overcome these difficulties, an analog method has been developed with the main purpose of conveniently measuring the distribution of heat density. For that purpose, a scaled down model of a typical large size production furnace was built in which the three arcs are substituted for by small electric light bulbs. Their light, which is equivalent to the heat of a real furnace, is measured by a self-generating photocell which can be moved over the entire inner refractory surface of the model. The experimental setup consisting of furnace, power supply and instrumentation is shown in Figure 3.

In order to make the analogy as realistic as possible,

Figure 3 — An experimental setup was used to determine the radiation intensity at various points on the furnace walls.



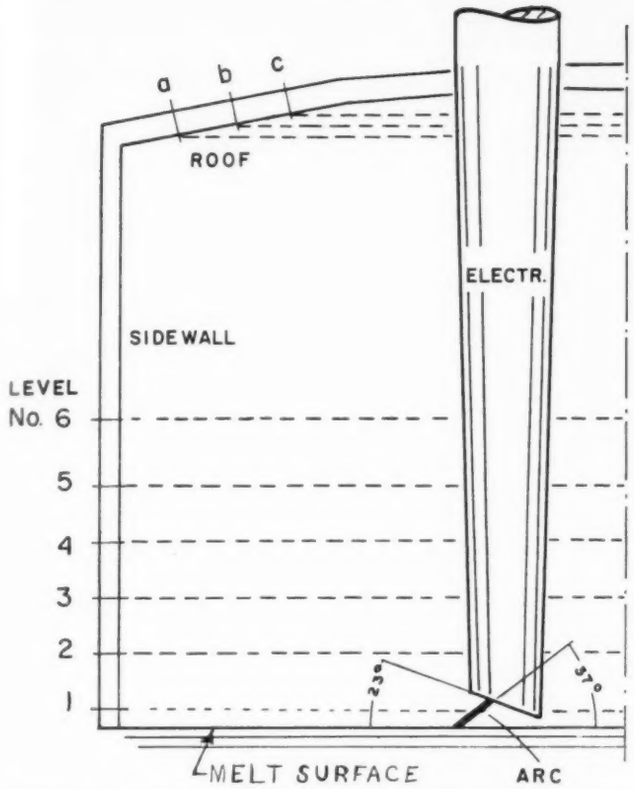


Figure 4 — A photocell was moved in nine paths to record heat intensity at various side-wall heights.

the following details have been incorporated:

Incandescent light bulbs are of the straight filament cylinder type. They are suspended from the tip of three electrodes in typical positions attained by arcs. The power for each bulb can be regulated by rheostats, which makes it possible to stimulate any degree of electrical power unbalance.

Three graphite electrodes are suspended from the roof, and they are artificially tapered. Since they do not oxidize as in real operation, their surface is painted with a dull paint, in order to simulate the surface roughness and ash deposits of actual operation.

The shell of the model is made of a hard cardboard with a surface roughness and emissivity similar to that of refractory material.

The metal surface is simulated by interchangeable false bottoms, with low or high coefficients of reflectivity; therefore, slags or metal surfaces of different reflectivities can be simulated. Furthermore, provisions are made to simulate a clean or a smoky surface atmosphere.

Prior to the tests, the photocell had been calibrated and checked with respect to color sensitivity and angular response. It can be moved into any position on the side wall or the roof of the shell. The output of the cell is measured with a millivolt-recorder which registers the voltage drop across an external load resistor connected across the photocell. The millivolt recordings are proportional to light intensity.

Test results—As shown in Figure 4, the photocell is moved on orbits along the inside of the side wall at six levels ranging from the slag line up to about one half of the height of the shell. Conditions on the roof are measured by following the three circular paths a, b and c.

In a preliminary test, this method was checked against the calculations shown in the preceding part. As for the calculation, balanced arc power was used in the model. To approach the theoretical conditions, electrodes with horizontal tip end faces were used in conjunction with the light bulbs vertically positioned in the prolonged axis of the electrodes. The results of arc A are shown in Table I. (The results for arcs B and C are identical.)

TABLE I
Vertical Arc Position—Horizontal Electrode Tips

Location, degrees	Heat density of arc A		Total heat density of arcs A + B + C	
	Calculated	Measured	Calculated	Measured
0	1.00	1.00	1.81	1.80 hot spot
15	0.97	0.92	1.78	
30	0.88	0.81	1.74	
45	0.76	0.71	1.68	
60	0.66	0.62	1.66	1.60 cold spot
75	0.57	0.55	1.68	
90	0.49	0.48	1.74	
105	0.44	0.42	1.78	
120	0.41	0.38	1.81	1.80 hot spot

The results indicate that the measured differential of 12.5 per cent between the hot spot and the cold spot is larger than the calculated one. Furthermore, the measured gradient of H in the vicinity of the hot spots is considerably steeper than calculated, indicating that hot spots are likely to be more localized than evinced by calculation.

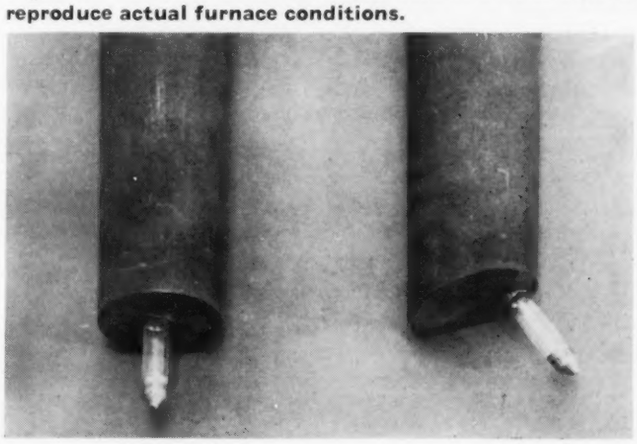
The following tests concern conditions as encountered during the latter part of meltdown in practical operation: the electrode tips are burned off at an angle of 23 degrees (Figures 4 and 5) and the arcs assume a slanted position. This condition prevails during the most critical period at the end of the meltdown because of the high level of arc power without scrap shielding the refractory.

Figure 6 shows the results of such operation with balanced arc power under two different conditions:

1. A bath covered with impurities or slag of low reflectivity.
2. A bare bath or a bath covered with highly reflective slag.

On these diagrams the heat density (H) is plotted in arbitrary units against one third of the furnace refractory circle (0 to 120 degrees). The Y axis values are shown in millivolts corresponding to the photocell

Figure 5 — Slanted bulbs were also used in an attempt to reproduce actual furnace conditions.



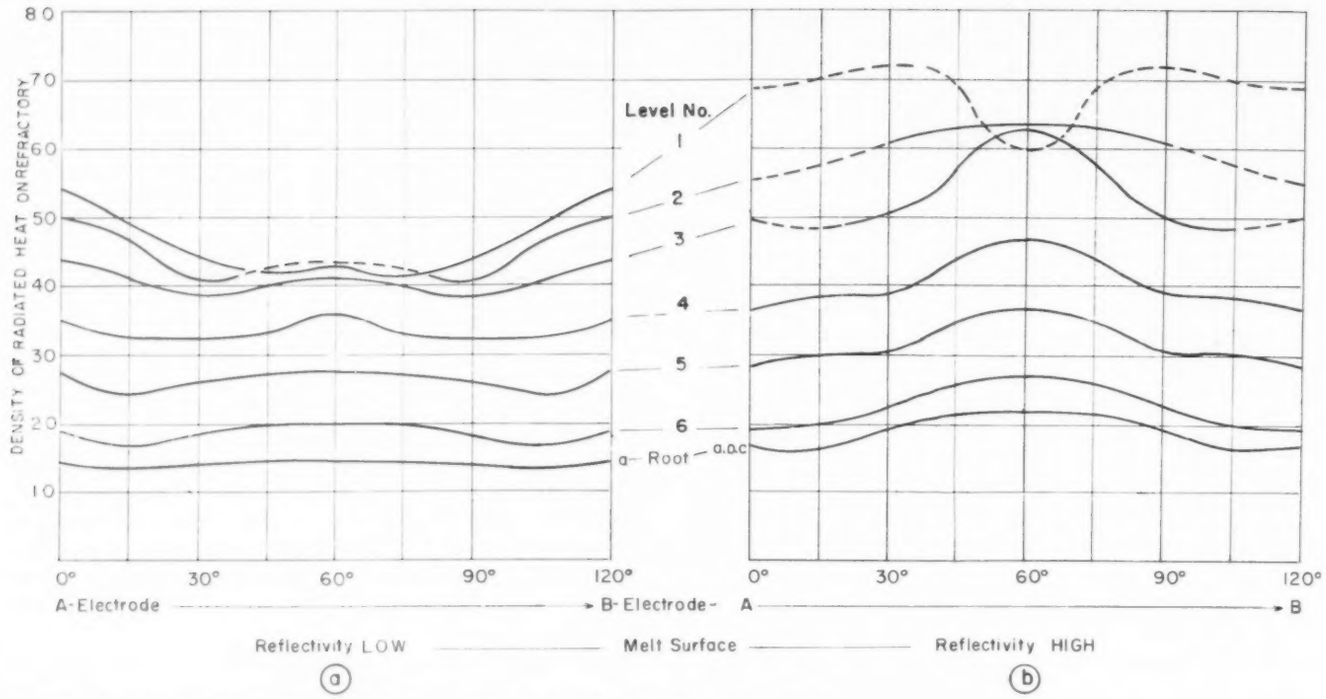


Figure 6 — The heat density will be a function of the reflectivity of the bath.

output. They can be readily converted into units used in Figure 2 on the basis that Y = 53 (No. 1 level at 0 and 120 degrees in Figure 6a) equals 1, by changing the scale accordingly. The various indicated levels refer to Figure 4. Level No. 1 curve taken near the slag line corresponds to the A + B + C curve of Figure 2 and the values of Table I.

On the halfway point between electrodes (Figure 6a) H is lower at No. 1 level, but is slightly exceeded by the corresponding No. 2 level value. It is very interesting that all curves show two minima, one on the left and one on the right from the 60-degree position. This indicates that the cold spots do not occur exactly at the 60-degree mark (180 or 300 degrees) as suggested by the mathematically derived results shown in Figure 2.

Figure 6b shows the results for a melt surface with high reflectivity. The intensity values are distinctly higher than on Figure 6a which is explained by the additional reflection due to the nature of the melt surface. Furthermore, a general pattern which would be extremely difficult to derive by a mathematical method is found.

Table II contains values of the differential between maxima and minima of the curves shown in Figures 6a and 6b:

TABLE II
Flaring Arcs—Beveled Electrode Tips*

Level No.	d, per cent	
	Low reflectivity	High reflectivity
1	30	21
2	22	14.5
3	13	29
4	11	28.5
5	12	28
6	21	42
Roofs a, b, c	8	39.5

* Calculated using the following equation: Maxima (differential) d = (H maxima − H minima/H minima) × 100

Note that the differential of No. 1 level is considerably higher than the nine per cent differential calculated and shown in Figure 4.

Another test series was concerned with the effect of fumes and smoke in the furnace. It was found that the intensity (H) and the differential between hot and colds spots are appreciably reduced.

Experience in furnace operation is in good qualitative agreement with these results. The fact that in practice, hot spots occur primarily near one of two electrodes is due to power asymmetry and will be discussed further.

In comparison with the intensity lines of the lower levels (Nos. 1, 2 and 3) the intensity and its variations in the roof section appear to be minor. On the other hand, deterioration of the roof is a major factor in refractory maintenance. It may be speculated that roof wear is probably not so much affected by radiated arc heat alone as by combination with hot gases or vapors. This assumption appears to be verified by M. P. Fedock[3,4] who suggests that roof damage due to high temperatures and to spalling has been overemphasized, and that "it is not the heat but the humidity that makes the roof wear with the various oxides formed during the melting and refining process." Later work and observations at production furnaces by J. A. Brosovic,[5] however, indicate that this theory is still controversial and that more experimental work is needed to clarify the situation.

The foregoing examples illustrate the analogy method and results of several typical furnace conditions. In addition, refining conditions yeilding heat distribution patterns similar to those shown in Figure 6a have been studied.

INFLUENCE OF POWER ASYMMETRY ON HOT SPOTS

In electric arc furnaces, hot spots are often found near one or two of the three electrodes. The center

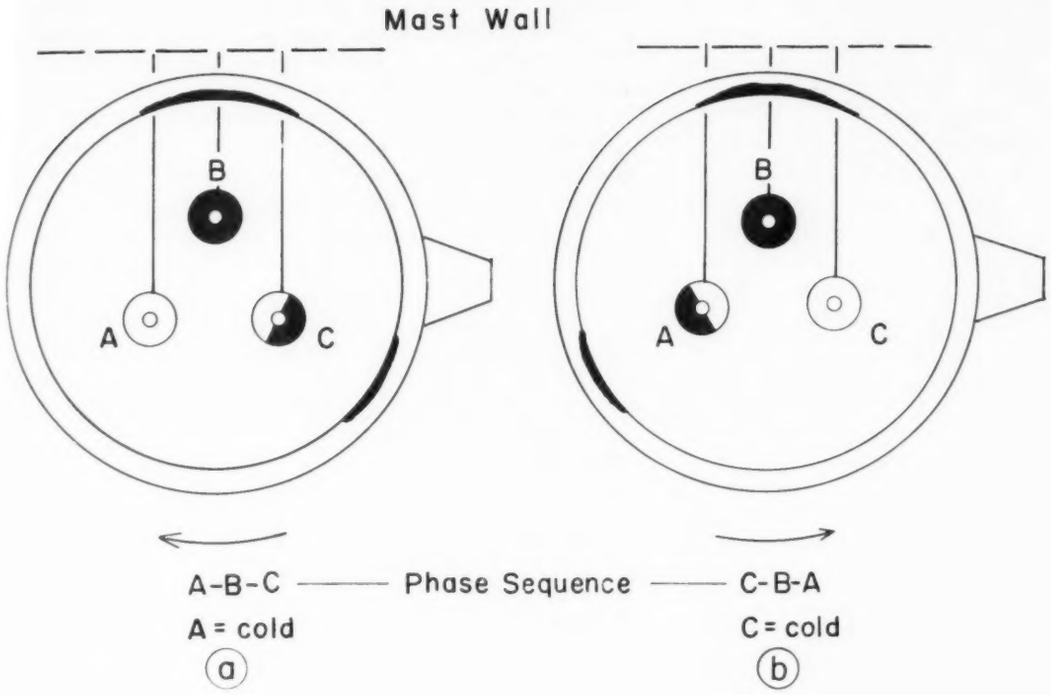


Figure 7 — Reversing of the phase sequence will change the outer hot spot.

electrode (B phase) tends especially to give a distinct hot spot. The reasons for the dissimilar power of the three arcs lies in the electrical asymmetry of conventional furnaces which has been discussed on other occasions.[6, 7] This distribution of hot spots is in accordance with the theory described in the references. It depends on the electrical phase rotation at the furnace. The results are schematically shown in Figure 7 for A — B — C and C — B — A phase sequence. The leading phase at the furnace, because of its lower power, radiates less heat upon the side wall than the other two phases. By reversing the phase sequence, the hot spot of one of the outer electrodes can be relocated to the vicinity of the opposite outside electrode, whereas, the hot spot of the center electrode (B) remains unchanged. This method of reversing phase rotation has practical significance in cases where side-wall patching through a furnace door can be carried out easier on one side of the furnace than on the other. Furthermore, it is at least theoretically conceivable that phase reversal after each heat would equalize conditions between A and C side-wall spots.

The main factor contributing to the described power unbalance is the side by side arrangement of conventional air-cooled flexible bundle conductors. Water-cooled flexibles require considerably less copper cross section per phase than air-cooled bundle flexibles. This, in combination with their insulation, makes it possible to arrange them in a fashion which results in electrical symmetry.[6] Furthermore, adequate arrangements permit compensation for the lower impedance of the center phase on furnaces where the electrode holder of the center phase is shorter than in the outer phases.

In the work with the furnace model, the power asymmetry as encountered according to the power characteristics of each phase of the original furnace was simulated with the result that the higher powered phases B and C (A — B — C sequence assumed) cause an increase of heat density over the underpowered phase, especially near the respective arcs (their influence upon the hot areas of the other electrodes is comparatively low and can be neglected).

By and large, maximum heat density near the electrode is governed by the ratio of arc power to the square of the distance between the arc and the critical point on the side wall. From practical experience it appears, however, that this criterion needs another refinement, possibly including the arc length, as for example, expressed by the effective arc voltage. It is known that long arcs at a high tap voltage (or at low currents) yielding the same power as shorter arcs with higher currents and lower voltage can be more harmful to the refractory.[8] More work is under way and results will be reported at a later date.

ELECTRODE REPOSITIONING

The previously discussed power unbalance in the arcs, in connection with the effect of the square of the distance suggests the possibility of arranging the electrodes of the hot phase closer to the center of the furnace and the possibility of moving the cold phase electrode farther in the direction of the side wall. One example of repositioned electrodes in accordance with principles of the photo-electric analog method is shown in Figure 8.

In this case, it is suggested to move A and B electrodes toward the center of the furnace, whereas, the position of C electrode (cold phase with C — B — A phase sequence) remains unchanged. However, if the melting rate at the cold phase is too low the electrode can be moved closer to the side wall. This would prevent forming of a scrap bank at this location and benefit the over-all melting rate of the furnace.

Since repositioning of the electrodes involves relatively small changes of the distance between the electrode tip and the side wall, it is possible to obtain the desired correction by canting the critical electrode. This method appears to be feasible for trials only. Its principal disadvantages are increased mechanical stresses

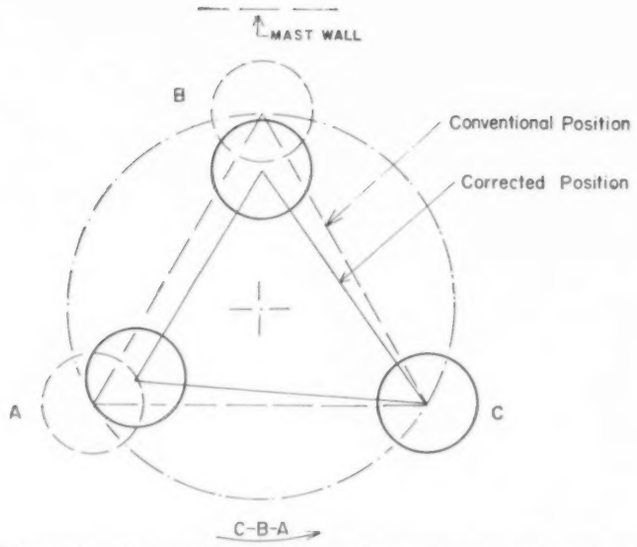


Figure 8 — Repositioning of the electrodes can reduce hot spot temperature.

in the electrode column due to a bending moment, and possible friction between the electrode and the roof port.

Another compromise method consists of using an electrode of smaller diameter on the hot phase. As a consequence of the smaller diameter and increased penciling due to higher current density, the arc is moved closer to the center of the furnace. It should be stressed that this method needs careful evaluation of the power and current conditions with respect to the current carrying capacity of the electrodes.

In a similar way, hollow electrodes[9] transpose the arc closer to the axis of the electrodes, thus increasing their distance from the side wall. In addition, the concave tip provides a shield for the heat rays directed upward. Their effectiveness depends on furnace size, arc power, etc.,[10] and usually leads to higher electrode consumption per ton of product.

Repositioning of electrodes, as illustrated in the example of Figure 8, slightly accentuates the electrical unbalance of the furnace power system, however, this is negligible.

Another interesting solution has been proposed by H. J. Eitel,[11] who suggested a side wall consisting of three sections each having a radius commensurate with the power of each arc. This leads to an irregular shape of the furnace cross section which complicates refractory maintenance.

SUMMARY

This article is an attempt to establish some fundamentals of heat distribution in electric steel furnaces. It was shown that the distribution of arc heat radiation on the side wall and roof refractory can be readily analyzed by a photo-electric analog method. In the light of experience on production furnaces, it appears that this method yields more realistic results than a strictly mathematical method.

Hot spots on the furnace lining are due to heat concentrations in certain areas of the refractory near the electrodes. Electrical unbalance, inherent to most furnaces, accentuates heat concentration mostly in one or two critical hot spots. On the basis of the above-described relationships, there are several methods of equalizing the heat in furnaces, such as establishing power balance by water-cooled flexible cables and repositioning of electrodes.

It is hoped that this article will stimulate interest, in this aspect of furnace practice, on the part of furnace designers and operators. More work is under way and will be reported at a later date.

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Discussion

PRESENTED BY

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E. J. BORREBACH, Sponsor Engineer, Westinghouse Electric Corp., East Pittsburgh, Pa.

J. A. Brosovic and I. G. Orellana: Republic has examined this problem on several production furnaces ranging from 70 to 200 tons in capacity. The investigation findings, in general, verified that electrical phase sequence was a major contributor to arc power level unbalances. Physical length differentials of the secondary transmission circuit also contribute to the arc power level unbalances.

However, long-term investigation of the furnaces revealed that unstable electrode regulation was far more

guilty of causing hot spots than the inherent electrical characteristics of the furnace circuit. An investigation involving four top-charge furnaces revealed that the regulating systems required adjustment at 90-day intervals to maintain minimum hot spot activity. It was difficult to ascertain whether this phenomena was due to inherent regulating system instability or other action occurring within the secondary transmission circuit. The results, however, suggested the need to improve the manner in which control signals are extracted from the furnace.

Would the author care to comment on:

To what extent was magnetic deflection of the arcs included in determining the location of the simulated heat energy sources in the analog study?

In the interest of preserving furnace efficiency and economy would it not be better to develop a means of deflecting the arc away from a hot spot zone rather than throttling its power input by added impedance?

To what extent will the increased inter-reaction of magnetic fields in the arc zones overcome the benefits of the corrected electrode position illustrated in Figure 8?

If the heat density is concentrated at the points as illustrated in Figures 2 and 6, is it not possible that the scrap melts very quickly in these areas and thus causes a substantial portion of the hot spot damage during the very early stages of the meltdown?

W. E. Schwabe: During the experimental work, external magnetic control of the arc was not a matter of concern. Magnetic arc deflection as caused by external fields is a very complex problem. Influencing the position of arcs by external magnetic fields was tried in Russia some 30 years ago where a single-phase furnace was equipped with a coil surrounding the lower part of the furnace shell and parts of the furnace bottom. Current was passed through the coil and the resulting magnetic field had a definite effect on the position of the arc. Initial experiments looked very attractive, but subsequent tests on a larger furnace proved to be a failure. The difficulty lies in the fact that creation of enough external magnetic flux in the vicinity of the arc requires extremely high currents, which are not practical.

As to the interaction of magnetic fields created by the arc currents, arc flare is approximately proportional to the square of the current and inversely proportional to the distance between the arcs of the three phases. From this relationship it can be concluded that a corrected electrode position, for example a decrease of the distance between arcs by a few inches has only a minor affect upon arc flare, whereas the effect on the radiated density on the side wall is of considerably greater magnitude.

It is felt that melting in the hot phase progresses faster than in the cold phase. Because of the gradual downward movement of the scrap during the first part of meltdown, the side wall is probably not overly exposed to open arc radiation. It has been noted that refractory damage occurs mostly in the latter part of meltdown and during refining when a flat bath is reached, and the arcs can freely radiate upon the side wall and the roof.

A. C. Forest: At the Los Angeles plant there are two 20-ft shell diameter furnaces and one 17-ft shell diameter furnace. The two large furnaces have transformers of 25,000-kva rated capacity, and both tap an average of 105 tons per heat. These furnaces average 25 to 26 megawatts of power input during meltdown.

Experience supports the opinions of the author that the arc power does most of the refractory damage. This has been as severe as 16 to 18 in. of refractory in 40 heats.

The main approach to overcoming this hot spot condition is to control the arc length by voltage and current adjustment of the different phases and taps. One trouble encountered in this practice is a tendency to overcorrect, resulting in bottom and bank trouble and overheating of the secondary cables and bus system.

Another approach was to cant the electrodes away from the hot spots, which helped correct the condition but resulted in physical damage to the roof electrode ports. This also resulted in excessive wear in certain areas of the masts and rollers, making it impossible to maintain the correct adjustment to control the whip or play of the electrode arms.

Considerable hot gunning of the furnaces is done, but this is a case of repairing the damage, not eliminating it.

It is known that the fume removal system contributes to refractory erosion, but the extent is not known. An example of this is:

No. 2 furnace had a side wall hot spot on A wall and a roof hot spot at C area. It was desired to move the side wall hot spot to C wall for easier gunning repairs, so the transformer phase rotation was reversed and the side wall hot spot moved from A wall to C wall but the roof hot spot remained in C area.

Operation of the furnaces with the electrode amp loading balanced on all three phases was tried. This caused excessive burning on B and C walls so the unbalanced amp loading was restored.

Insertion of a thermocouple through the shell into the side-wall refractory was tried. Some good results were obtained and it was felt that possibly this is the most practical way to solve the refractory troubles.

W. E. Schwabe: Canting of electrodes should not be considered as a permanent method of solving the hot spot problem. Canting of electrodes also leads to unnecessary stresses in the electrode column because of the force components in the vertical and horizontal directions.

In cases where repositioning of electrodes is considered it is very likely that roof port locations also have to be repositioned. As far as measuring the actual refractory temperature by thermocouples is concerned, it is felt that this is a very important step in the direction of co-ordinating power and refractory utilization. Thermocouples do not permit a direct full-range measurement of the actual side-wall temperatures because of their limited temperature range. However, they offer the possibility of measuring a temperature in-between the exposed area of the refractory and the outer shell. This method has the disadvantage of introducing a time delay in the measurement. This method was tried, and thermocouples welded on the furnace shell in the center of the hot spot areas were used. It was found that the time delay between reaching maximum temperature at the inner

refractory and the corresponding point on the shell is approximately 15 to 20 min.

W. C. Franklin: Would the author care to comment on the effect of slag condition on the hot spots? Is it felt that the slag condition, that is whether the slag is fluid and glassy or deep and fluffy, tending to smother the arc, has a great bearing on minimizing the hot spot condition?

Does the author agree that excessive power will damage the refractories abnormally, along with causing higher electrode consumption?

With regard to moving the electrodes, does not this create a problem with the electrode ports in the roof? In our case they have to be held to a minimum size and also matched with a subroof for the fume and smoke control system.

There is much interest in the author's comments on the B phase cutting the refractories, since we have this very same problem. Does the author agree that, being unable to get scrap as dense in the area of B phase due to most electric furnace designs and charging practices, has something to do with the B phase cutting the refractories?

W. E. Schwabe: The thickness of the slag is an important factor. It is known that deep slags submerge the arc and reduce heat radiation on the refractory considerably. Furthermore, the reflectivity of the slag is of great importance. In this connection it should be borne in mind that the reflectivity of a surface is dependent on the wave length radiated by the source, in this case the arc.

If high arc power is established by high currents, electrode consumption may increase appreciably.

Mr. Franklin's last question implies that scrap density is consistently nonuniform in the area of the three electrodes. Observations on various electric furnaces have not indicated that such an inconsistency of scrap density exists. It is felt that effects of differences of bulk density of scrap will equalize statistically over a period of time.

R. W. Holman: At some locations, operators are adding oxygen to the electric furnace to speed up the refining of steel. Does that have any marked effect on refractory life?

W. E. Schwabe: Using oxygen in the electric furnace means introducing more Btu per unit time due to combustion. Oxygen lancing yields a fairly large flame of relatively uniform temperature distribution plus a large volume of hot gas. It is likely that these two factors have an effect of increasing the average temperature of the refractory. Therefore, when the electric power is shut off and the position of the oxygen lance changed frequently, the flame should tend to equalize the temperature differences established on the refractory surface by arc radiation. In the case of simultaneous arcing and lancing, the arc heat superimposed over the lancing heat will tend to maintain the temperature gradients on the refractory surface.

E. J. Borrebach: Unbalanced heating arises because furnace operators will naturally attempt to balance the currents in the three electrodes of the furnace. Unequal impedances in the three phases result in unbalanced power input under this balanced current condition. There have been several attempts to overcome this problem.

J. A. Brosovic[1] described how he has attempted to balance the kw input per electrode through the use of kwhr meters in each phase. By balancing the kwhr of energy transmitted by each electrode over a period of time he attempted to balance the kw operating level of the three arcs. Such a watt balancing system does not attempt to balance the impedances of the three phases. For this reason the voltage drop and the current magnitude in the three arcs would have to differ. This would result in three differently shaped arcs even though the kw operating level was the same in each arc. Thus this method of balancing power in the arcs need not result in like patterns of heat distribution. The amount of energy delivered to the bath, side walls and roof would vary in accord with the shape of the arc.

An attempt has been made to balance arc power input per phase through impedance balancing by adding reactance into the hot phase of a furnace. This method seems to be very effective. It provides a high degree of load balancing so that, over a wide range of power input level, reasonably balanced conditions can be maintained. It is felt that the impedance balancing method of eliminating furnace hot spots will grow in the next few years to become the usual method to overcome the hot spot problem.

The author stated that the furnace system resistance seems to be much higher than calculations would indicate. A very excellent paper presented before the AIEE[12] showed that in a 3-phase arc furnace system there will be a reflected resistance from one phase to another. This reflected resistance will mean an increased resistance in one phase and therefore a reduced arc power level in that particular phase. Perhaps this effect accounts for the discrepancy the author mentions.

W. E. Schwabe: When an increase of resistance was mentioned, reference was made to the average operating resistance of the air-cooled flexibles. Taking the effect of the reflected resistance into consideration, it was found that the actual watt producing resistance of the flexibles was considerably higher than calculated values would indicate. In the calculation, temperature and skin effect were considered. It would appear that these high resistance values can be explained by pronounced proximity effects between the phases and/or between conductors and structural members of the furnace, such as shell, masts, etc.

Adding reactance to the center phase reduces the arc power of that phase, without curing the influence of the reflected resistance affecting the two outer phases. The problem of phase balancing should be aimed at raising the arc power of the cold phase and lowering that of the opposite outside and center phase, under full utilization of the available transformer capacity. In a number of commercial installations, it has been found that the reflected resistance is of the same order as the physical resistance of one phase. It is vector-additive to the physical resistance in the leading outside (cold) phase and vector-subtractive in the lagging outside phase. Eliminating this effect calls for equalizing the coefficients of mutual inductance between the conductors which can be accomplished to a considerable degree by certain geometric arrangements of water-cooled flexibles. ▲

the next step in Steel Plant Data Processing

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. . . . a wide range of computer applications has been evolved in the few years since the computer has come of age . . . . perhaps the need to supply information to the computer as fast as it can use it will hasten the wide-spread development of high-speed communication systems to permit maximum computer usage . . . .

THE successful entry of computers into the selling and production affairs of steel companies during the past five years has been one of the dramatic technological breakthroughs in the industry's history. Though it is unrealistic to regard the data processing problems of the steel industry as solved, the great number of productive computer applications and the accelerating development of sound concepts make it clear that electronic data processing will play a major part in the operation of business. In spite of the frustrations and miscalculations that attend any pioneer effort, the promise of an entirely new level of effectiveness in producing and selling steel appears to be justified.

However, the very success of the computer projects is intensifying the problem of physical communications in steel plants and in steel companies as a whole. The pressure on communications is becoming so great that the next five years is likely to be a period of radical development and application in communication networks, comparable to the surge of computer applications in the years just past. Not only is there great need for improved communication, but, fortunately, there is also a wealth of new devices and concepts waiting to be adapted and applied to the problems.

The need for better communications lies in the nature and purpose of the computer applications which are becoming common. These applications occur at two levels. The first is the level of the so-called "total system." This is the area of the data center, the medium or large-scale computer and its accessories. This computer is typically housed in a specially constructed set of rooms, or in its own building. It has its own technical staff to attend it, feed it and interpret its output. It can follow and analyze the logistics of sales and production with amazing speed. The second level of actual application is that of the process control computer. This is at the level of the card-programmed mill and the automatic data logger. Though quite complex, it is compact. It is located at, or in, the production unit which it serves. Presently, it is much more nearly automatic than the data center. Moreover, it has its own direct sensing components in the form of measuring devices, and it often operates in real time with respect to the producing unit it serves.

Furthermore, both of these levels are developing the ability to accumulate and evaluate control information at a rate which outstrips the ability to communicate, with the result that much of the potential value of the new systems is locked up at the location of the computer. This difficulty will be intensified as the computing systems become better, unless communication channels are improved in step with the progress in data processing.

A good illustration of this dependence upon communications lies in the field of providing steel rolling and shearing instructions. There are now several computer programs which will calculate the ideal sizes and shearing layouts for any given group of orders. These programs are rapidly being refined and simplified. There is every reason to expect that soon they will cover virtually all products, and that they will be quite fast and inexpensive. They have already improved yields considerably. However, the full potential of these programs is not being reached. They are applied only to the assumed ingots, slabs, billets, etc., as these are planned in advance. When the actual ingots, slabs,

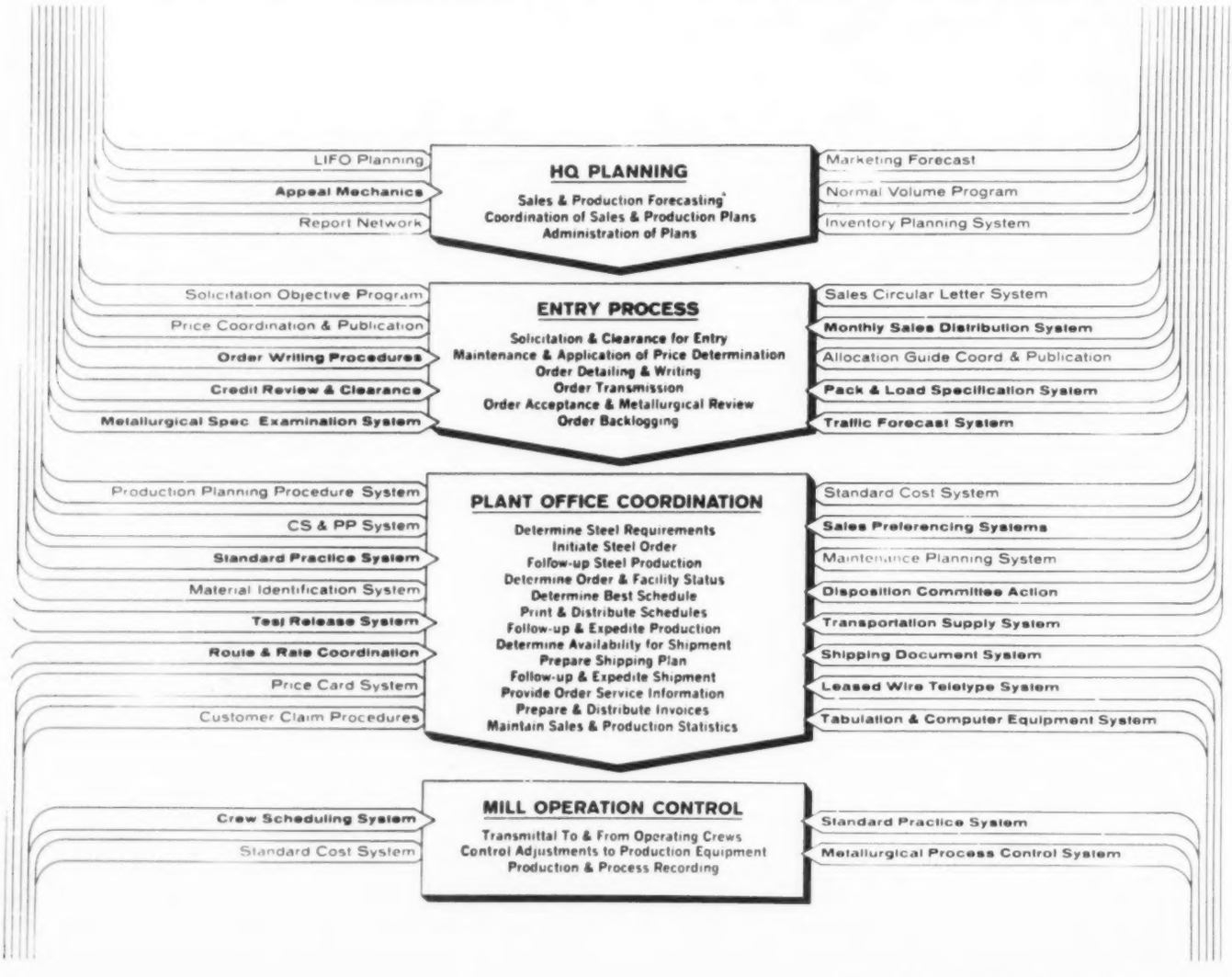
billets, etc., are significantly different from those planned, the original shearing instructions may cease to be the best, and suddenly become the worst. What is needed then is to recompute and find the best new combination. There is no essential difficulty in doing this so far as the computer itself is concerned. So far, it cannot be done, because the communications channels between mill units and data centers do not operate fast enough to get actual production data in and new instructions out before the material arrives at the shear. As data centers and process control computers are refined, this time discrepancy will extend to more and more functions, unless communication networks are drastically improved.

The present communication systems were not constructed for these new purposes: they could not have been. Most of them were developed more than a decade ago at a time when industrial computers did not exist.

The present systems can be roughly classified into three groups. The first group serves the purpose of conveying human voice. Probably the most widely distributed of all communication devices is the telephone, which reflects the fact that under all circumstances a major part of the co-ordination in an organization depends upon men talking to each other. This seems not likely to change; a steel plant in which no one ever has any occasion to talk to anyone else is very difficult to imagine. The telephone services are for the most part leased from, and serviced by, the public telephone companies, and of course they are tied directly into the entire public telephone network. In addition to telephones there are many smaller voice systems of the inter-communication type, particularly between the operating stations of a single mill crew. In a few cases, 2-way radio systems are also used.

Another class of present systems are those which convey printed and typewritten reports, messages and instructions. One of the most familiar kinds of these are teletype networks which are used both within the plant, and between plants and the other offices of the company. However, the teletype ordinarily handles only a small fraction of the document traffic; most document traffic is carried by messengers and mail service. Within the plant, messenger services of all sorts are very common, and outside the plant much use is made of the U. S. mail. Reports and messages are also carried between a few critical points by relatively small tel-autograph systems, by pneumatic tubes and by conventional facsimile systems. In a very few cases some use is made of continuous belts and other automatic conveyers to move documents from one point to another.

Figure 1 — The general pattern of an order system shows the relationship of associated systems to principal order flow.



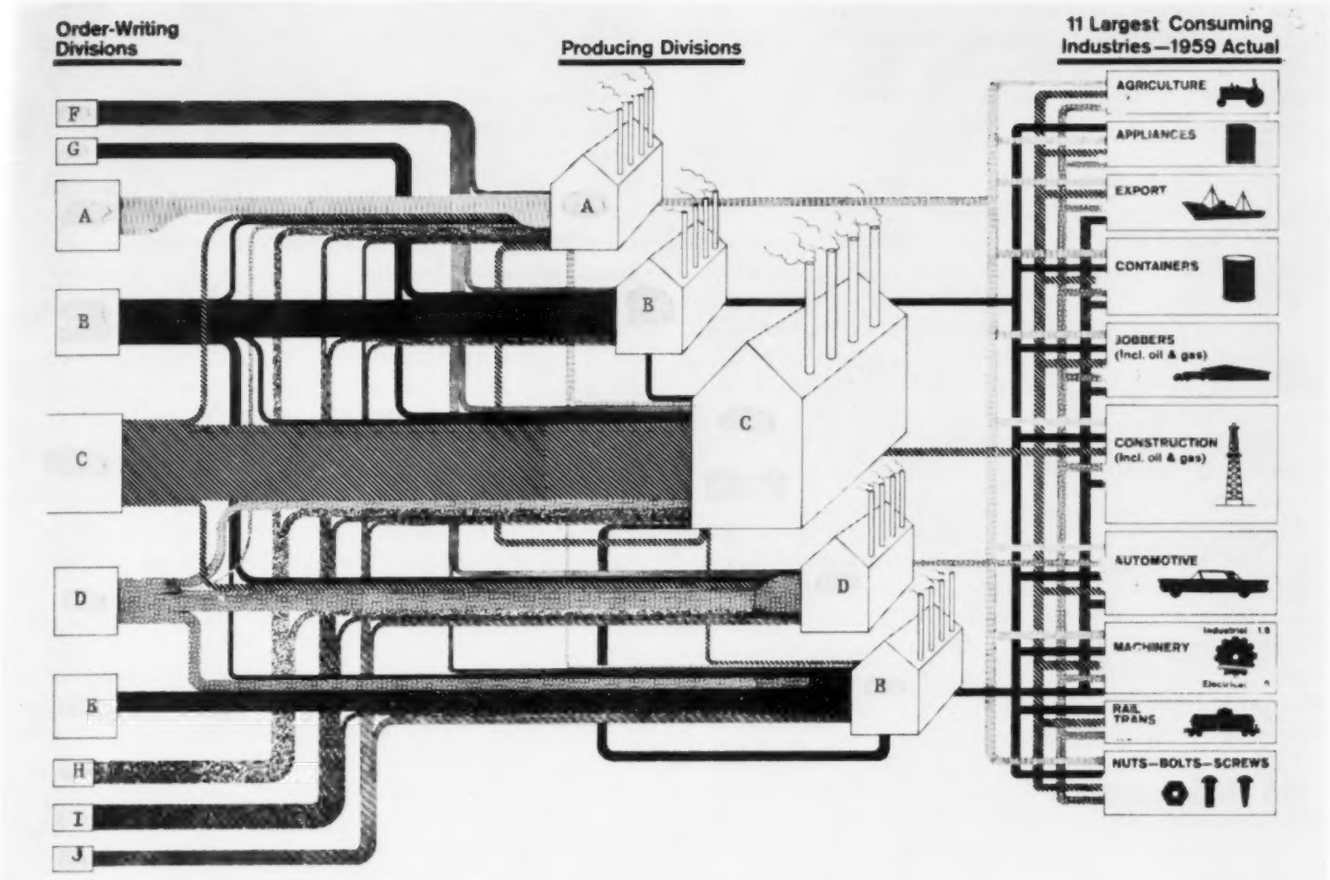


Figure 2 — To provide good customer service, a large number of order-writing divisions must exist, and they must be able to determine the proper order action.

A third general class of communication devices are the remote indicators and recorders. There is a great variety of these, most of which are electrically or electronically operated. Some are pneumatic and a few are purely mechanical and visual. Some in this class are quite sophisticated, i.e., industrial television which is commonly used for remote observation of difficult or dangerous places. The various transducers which pick up physical measures or counts and pass them into data loggers or control computers may be included in this class.

In total, these facilities are capable of handling great quantities of information but only at relatively slow rates when compared with the demands of the new control systems. Many of them probably will be found adaptable to the newer needs of communications, but only after analysis of the total communications system reveals the part each should play.

If all of these channels of communications were blocked on a map for a given company or plant it would be apparent that they had been developed a little at a time as this or that need appeared. It is in fact very difficult to approach the steel plant communications problem on a total or integrated basis simply because of the scope and complexity of the necessary communications, but in sales-production affairs it is becoming more and more important to adopt the over-all viewpoint and to engineer specifically for the greater requirements of the so-called total systems.

A beginning concept of the difficult analysis which is needed may be gained by considering the entire company network which centers around the order system in the steel industry. Although there is some manufacture for stock and some sale of standard products in the steel industry, the major part of the production is literally and directly for individual customer orders. Therefore, the individual order has become the principal vehicle for combining all the instructions and arrangements necessary for manufacture. In its final phase, the order flows into and through the operating departments of the plant and literally directs and controls the production. To see some of the complexity of steel company order flow, consider the simplified chart (Figure 1) and bear in mind that this flow must be followed individually by some millions of customer order items annually in the U. S.

There is first in this figure the block at the top, the headquarters planning phase, which basically covers sales and production forecasting, co-ordination of the sales and production advance plans and the administration of plans. This phase is followed by the entry process, represented in the second block. This is the process, beginning in the sales office and extending into the plant, by which orders are originally booked. The next block covers plant office co-ordination, by which is meant all the arrangements made at desks and offices within the plant, or at the scheduling point if this is outside the plant. These operations include production planning arrangements, the metallurgical arrangements, the accounting arrangements, etc. Finally in the last block is represented the area at which all preparatory work is aimed, the control of mill opera-

tions, both for economy of production and for maximum customer service. This is the path that each customer order item transaction must follow. This main stream represented by the four central blocks is a sufficiently complex thing in itself, but it does not stand on its own feet.

The main flow depends on, is fed by and feeds back into, a great series of other systems. Each of the lateral channels which flow into the main channel is in itself a full blown system, in many cases requiring the effort of an entire department or division. For example, note the metallurgical specifications system which is shown flowing into the entry process, which is a system that is apart from the main flow of the order system, but which must operate accurately and in timely fashion so that it will make available to the order system the exact information needed for precise orders at the exact time it is needed.

Moreover, notice the number of such systems which must flow into the entry process in synchronized fashion, and then notice all the further systems which enter into the latter stages of processing. A flaw, either in the main flow or in any one of the tie-in systems, will mean that some customer's order gets made wrong, or delayed, or not made at all, or that the plant goes through an inefficient operation.

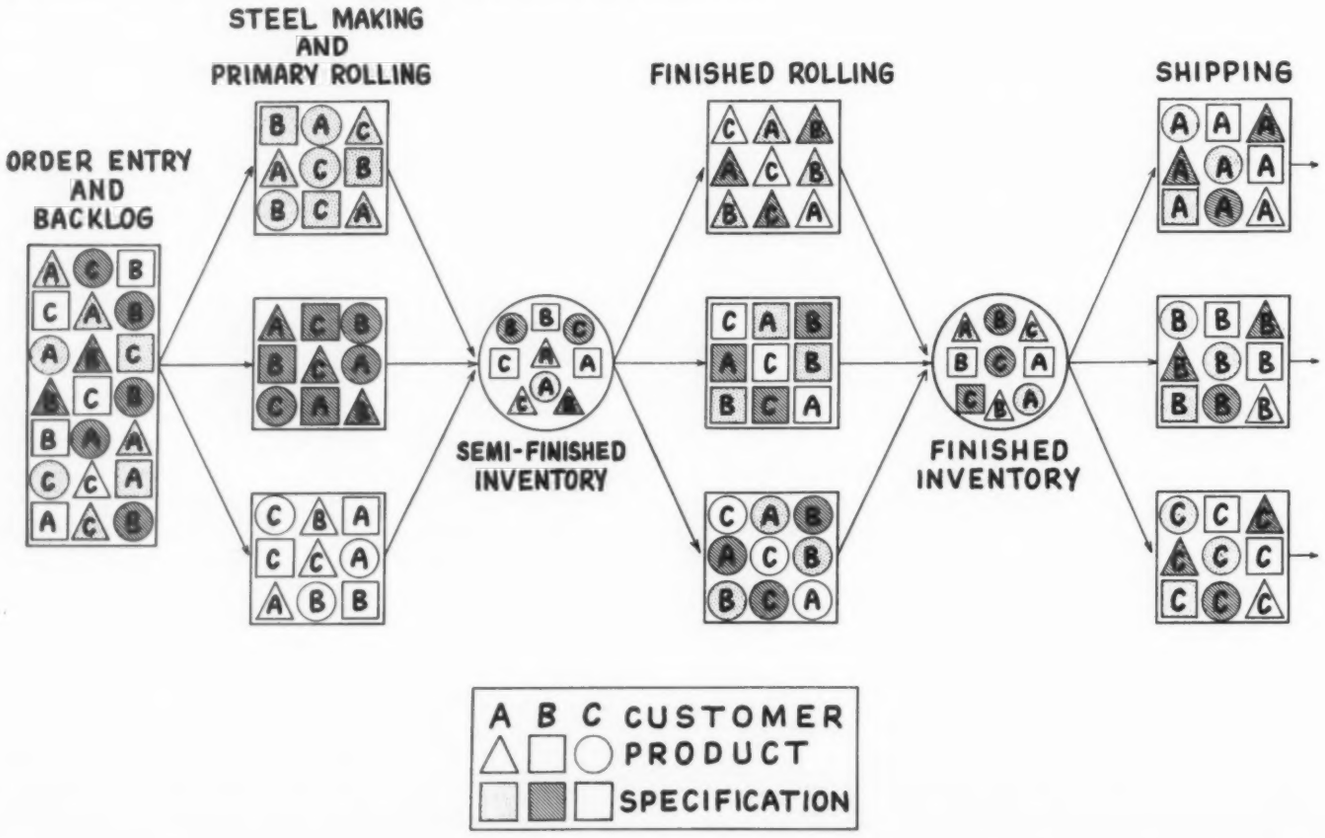
From a slightly different view the chart in Figure 2 shows another type of path along which orders must flow. Many of the integrated companies in the industry have this wide spread of selling points combined with a number of producing points, although of course, the exact organization of sales and production is not the same from company to company. In fact, a great proportion of the high level of service to customers rests upon the ability to offer any customer, wherever located, access to the producing point best qualified to serve him. Yet, the very scope of a network which can provide this kind of service imposes severe communications problems. Especially is this true in an industry in which the individual order of the customer enters so intricately into the production process itself.

The network indicated in Figure 2 is greatly oversimplified, but it indicates some of the complexity of this one level of flow, a flow which is fundamental in co-ordinating the sale with production of steel. However, it takes no account of an extensive and necessary flow within the producing plant.

Within a large plant, the flow of discreet lots of ordered material and the parallel flow of control information almost defy meaningful charting. However, some conception of the nature of these flows can be gained from Figures 3 and 4.

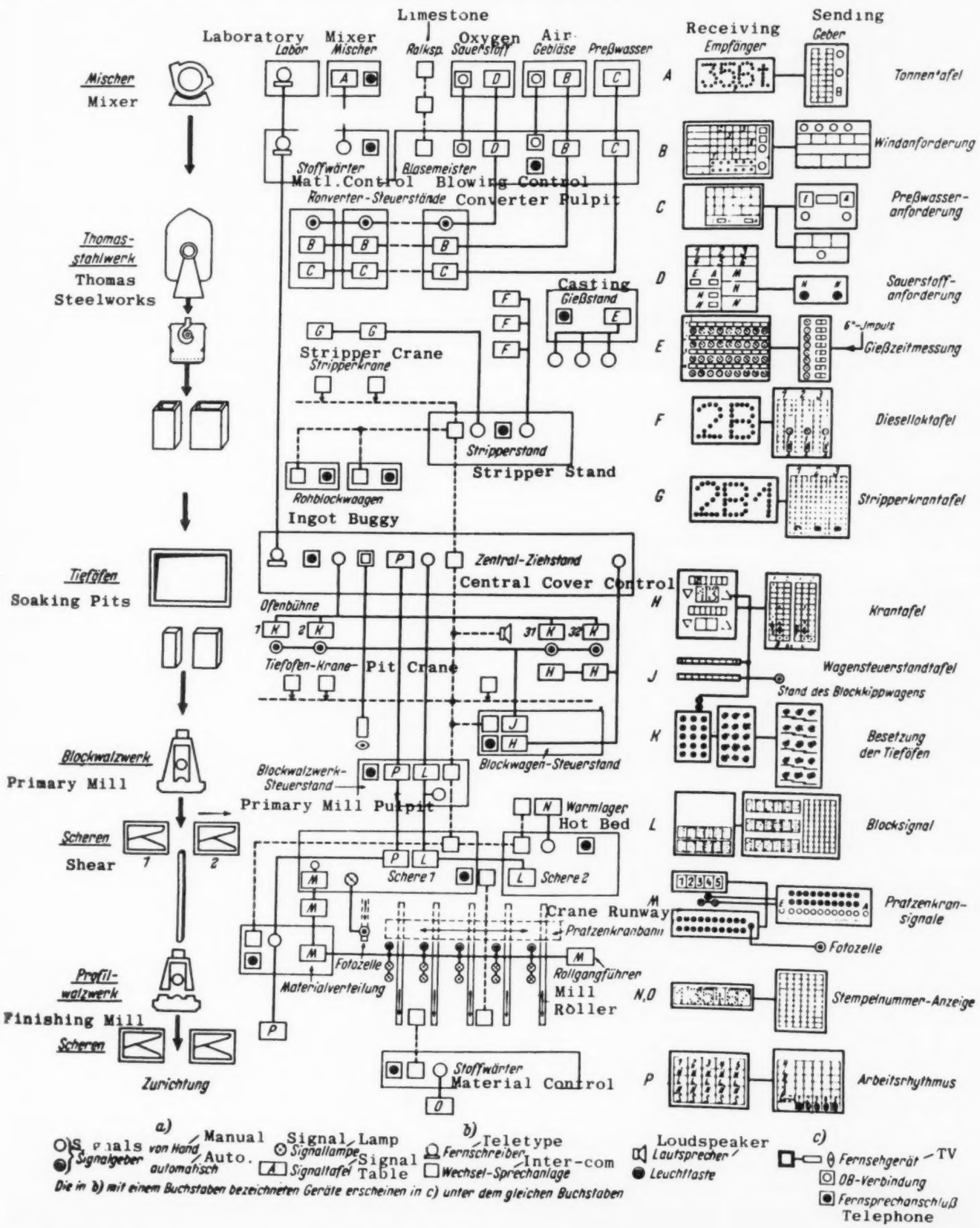
Figure 3 represents schematically the successive recombinations of ordered items at the principal stages of production. The left hand column represents an order backlog containing items which are individually distinguished; by shading, to indicate specification or grade; by shape, to indicate product and section; and

Figure 3 — In the column on the left the order backlog is assembled and coded by material specification, shape and customer. The second column indicates that like specifications are grouped to expedite melting and primary rolling procedures. The third column then shows that finishing mill rolling schedules are set up to handle like shapes even though material specifications are different. In the last column the orders are sorted according to customer and destination, with the customer receiving varied shapes of several different specifications.



by letter, to indicate customer. At the melting and primary rolling state these are necessarily grouped and physically handled according to specification in heat lots; i.e., all whites combined, all grays combined, etc. Passing through semi-finished yards these must be physically sorted and regrouped for the finishing mills, where groups of the same cross section will be handled, i.e., all the rounds of a given size together, all the squares of a given size together, etc. In the finishing departments the items must again be sorted and re-

Figure 4 — This steel mill communications network is in a European plant.



grouped physically to gather together for shipment all items for customer A, all items for customer B, etc. Usually of course, there are more than these three simple stages of manufacture and consequently there are other necessary physical combinations.

The entire flow indicated in Figure 3 is paralleled by a flow of information from point to point, from person to person and from group to group. This intelligence is necessarily so detailed that it constitutes a moving information analogy or model of the entire physical process. It serves not only the purpose of immediate direction and control, but also the purposes of planning, quality control, customer service and cost control, to name a few. The kind of communications systems often used to keep this information moving in the production areas is shown in Figure 4, in a simplified layout. Omitted from this chart are most of the office activities which are a necessary part of the chain. Moreover, the chart leaves out pneumatic tube systems which are used in this particular plant, and it omits the circulation of documents and written instructions. Remembering that once more this is a simplified view, note the variety and complexity of the communications devices. Many of the components are quite refined. The visible signal system, for example, makes use of lighted character display boards in which each character is formed from a 5 x 7 lamp matrix, so that a running series of numbers and instructions may be visible simultaneously to several members of a crew. Through all these devices, the inter-communications, the teletype, the television, the signal boards, and so on, moves the minimum information to keep a mill running. And with all this effort there is still no way of obtaining an over-all view of the plant operation at large, except through written or typed or punched records, which can be assembled only after a considerable lag.

The four levels, or aspects, of steel company communications which have been reviewed indicate broadly the needs which the new networks must meet. There is a good prospect that these needs will be met and that the industry is at the threshold of a revolutionary change in communications technology. Before that threshold is passed, there will have to be conception, analysis and engineering on a scale which has heretofore been impossible. A way of dealing conceptually with the whole actual range of the inter-connected systems from sales point through to product shipment and billing will need to be found. The notion of a total system can become fully operative in the steel industry only as communications can be designed to support it. The developments in physical technology seem to provide ample reason for optimism in attacking this problem, and some of the more striking recent developments are worth a brief review.

The pace of present communications development is indicated by some of the complete systems already in use or under test. The Post Office Dept. announced about a year ago that it had prototype equipment for long-distance transmission of letters by a television process, and it has confirmed by press releases during recent months that this system is now being tested with volume traffic. The system according to announcements accepts a sealed letter at the originating point, opens the letter mechanically without revealing the contents to the human operators, scans the message and transmits it at the frame rate of standard television, receives and prints a copy at the terminal end and finally inserts the letter into an addressed envelope and seals it. For high-volume channels over long distances the entire unit cost is expected to be only a fraction of the present mail costs, even though the channels used are in the megacycle band. The entire transmission cycle including terminal handling is cut from days to minutes. This system not only demonstrates the practical possibilities of new techniques, but is likely to have its own direct impact on the manner of handling business information between principal cities. Many other instances show the possibilities and the variety of the new approaches. Networks linking large computers directly to other computers over telephone lines are in operation both in business and in the military. The telemetering systems used with guided missiles have reached a stage of fantastic sophistication. Microwave-control communication along the path of interstate pipe lines has become almost commonplace.

The Netherlands postal and telegraph services have tested extensively in their postal savings branch a document which can be made by the ordinary depositor, but which can then be read as direct input to data processing and communications equipment. The County of Los Angeles is testing a vote-tallying system which begins with a machine-readable ballot of great size (as much as 17 x 22 in.) and with great variability in format. Newspaper articles indicate that the U. S. Weather Bureau is testing extensive networks for the transmission and display of weather maps. This brief list indicates that sharply improved communications are possible, and practical.

Behind the many new systems is a series of striking achievements in the components and researches which make up a system. There are so many of these that they cannot even be adequately summarized and classified in an article of this length, but in seriously considering the steel company network problem, it is necessary to indicate at least some of the possibilities. For this purpose the components may be divided into two classes; signal transmission equipment and terminal equipment.

The signal transmission equipment has been largely the responsibility of the public communications companies. Only by the sharing of these publicly available services has it been possible to provide an economical signal service which blankets the U. S., office by office and factory by factory. These public services, either on a toll basis or a lease basis, provide the core around which a company system can be built.

These signal services are themselves being radically improved. Increasing use of micro-wave transmission, wider and wider networks of coaxial cables, refinement and upgrading of frequency and amplitude characteristics, increases in available band-width, refinement and automation of switching arrangements and transmission utilizing satellites or celestial bodies are all raising the capabilities of the signal services enormously. However it is transmitted, the so-called "voice band" of about three kc is suited to do a major share of steel company transmission, simply because it combines a cost low enough to allow universal coverage with a capacity great enough to be matched with most of the necessary terminal equipment and with the

traffic volume on most links of the network.

There is great variety in terminal equipment because of the many situations to be met. There is no point in discussing any of the well-established types of terminal equipment such as telephones, teletype, card transceivers, facsimile, tel-autograph, 2-way radio, conventional industrial television, etc. All of these are likely to have a place in the new networks, but at least some of the less commonly understood new components should be reviewed to see the possibilities they introduce.

High on the list of the significant new components is the variety of cathode-ray display tubes. Many of these are now capable of retaining images faithfully over a considerable span of time, and this feature gives wide latitude in accommodating the speed of one piece of equipment to another, or in accommodating the speed of human comprehension to the speed of a machine. Some of these tubes can also form visible characters in a controlled format from almost any coded character input. This allows them to be used for direct computer or electronic memory output, which can then be printed, transmitted or comprehended directly in optical form. A further capability is that they can with great rapidity plot graphic materials and display them. Several companies have designed systems, using this principle, which will allow almost instant display of any programmed aspect of an extensive library of basic operating data, the basic library in turn being kept current by directly or indirectly connected communications lines.

Another very significant advance has been made in the field of communications printers. The image on a cathode-ray tube face is transitory. To preserve any selected image in optical form requires a printer operating directly from the tube face. A number of these have recently been developed in practical, economical form. One utilizes xerography activated by light from the tube face, and has been reduced to a workable, reliable machine. Others use the electrostatic principle of printing. One machine developed by the Stanford Research Institute uses a cathode-ray tube in the face of which is embedded a fine matrix of metal wires which direct the image forming electron beam through to an electrostatic printer. Other printers capture the image from the tube face by an automatic high-speed microfilm camera, the film then being projected or printed for human examination.

Many of these tube devices readily make the conversion from machine language to optical and human language, in addition to the ability of tubes to reflect an original optical input. However, they do not convert from human to machine language. Another class of machines is beginning to do this. A variety of character readers, some of them optical, some magnetic, are on the market or under development. The earliest machines were quite limited, some of them reading only numbers of a particular form. However, each year sees an expansion of capability, and it is likely that extremely flexible character readers will soon be in existence, some of them perhaps reading certain types of handwriting. When this is accomplished, the translation from machine to human and from human to machine language will be possible wherever it is needed.

Another class of machines, now available in several forms, carries out translation from one machine language to another, and in the process balances the operating speed of the two machines. There are many of these in the analog-to-digital area. One set of these, beginning to come into use, converts paper tapes or cards, or magnetic tape into a signal appropriate for telephone line transmission, with output at the other end in any desired digital form or code.

Still another significant development is in the field of camera tubes and scanners which pick up images for television. First there are slow-speed tubes and scanners which can operate at much slower speeds than conventional television and therefore, produce a signal of a few kc bandwidth instead of the megacycle bandwidth. Thus the signal produced can be carried over cheaper and more widely available lines. Transmission of still images would be at a rate of some sec per image. Especially for document transmission this rate seems ideal, either for display or for terminal printing. These tubes, of course, have an ability to store images during the time required to complete the scan, and some of them can read at one rate and write at another.

The greatest difficulty for document transmission is that the effective resolution of most camera tubes is in the range of 500 lines per frame, which is not sufficient for clarity in many documents. Both display tubes and camera tubes can be made which raise the effective resolution to 1000 or 1200 lines, and many display tubes are already so made. On the input side a number of flying spot scanners achieve this resolution, though they lack the other capabilities of camera tubes.

This brief discussion cannot do justice to even the principal components and lines of development which are newly available. It has gone no further than to try to indicate the quality, the pace and the possibilities of the current surge in communications work. Yet, one more aspect of the work must be touched upon before closing the list. Many of the companies and organizations included in this work are beginning to make specific and sustained investigation of the man-machine relationship, particularly the part of the relationship which involves a nontechnical man's comprehension of machine communications.

The reason for this concern is illustrated in this article. In the charts depicting over-all flow of steel company information systems, it becomes evident that men by the thousands are intimately involved in, and dependent upon, the communications network. Men are not merely tolerated in this network, they are, in a fundamental sense, its most essential and indispensable part. They are men of great skill and judgment in every phase of the business. It is not an exaggeration to say that virtually all communication originates with or ends with a man, if the information is useful. Yet, the further discussion in the article concerns a breadth and variety of machine complexity which may to most men seem almost a wilderness. It is to bridge this widening gap between machine complexity and human comprehension that many groups are seriously at work to incorporate human requirements realistically into network design. An instance of this effort is the Cobol project to use business oriented language in programming computers. Another instance is the setting up of

human engineering groups in equipment making companies. Universities are investigating various aspects of these problems. Government, particularly the military arm, is doing intensive work on these relationships. At a West Coast electronics conference, attended by thousands of engineers, a symposium on the man-machine relationship was held on each of the four conference days, more time than was devoted to any other subject. Henceforward, it is evident that communication network design will have to take into account the behavioral sciences as realistically as the physical science.

SUMMARY

It seems likely that an enormously difficult, but enormously rewarding, change in communications networks lies just ahead. The entire gamut of functions and locations reviewed in the simplified charts of steel company information flow earlier in this article must be served at the new levels which are possible with the new technical resources. The communications network needs to be integrated into a total system as surely as the data processing systems do. To accomplish this will require the active participation of skilled, imaginative people from every major function of the business. No function and no profession has within it the breadth of concept and knowledge required to achieve a satisfactory company communications system, which takes full advantage of the data processing capabilities now coming into being, or which takes full advantage of the management concepts which data processing makes possible.

What will the new systems look like? Probably no one can accurately foresee their complete nature because so much fundamental development is still being done, and because the underlying concepts are just now being formed. At least three characteristics seem within the realm of possibility and are urgently needed:

1. A true, single system in the sense that every part of the system can be directly connected to the signals of the rest of the system with as little human intervention as possible beyond the initial stage of human selection. The ideal would be fully automatic switching from any part of the system to any other needed part.

2. A system whose parts operate in the real time of the functions they serve. This would require that the most desirable cycle time of every physical production process, and every evaluation and decision process be matched by the cycle time of the communication cycles which support it.

3. A system in which every machine can communicate directly with every other needed machine; in which every man can communicate directly and easily into the machine network; in which every man can receive communications directly and easily from the machine network; and in which every man can communicate directly with any other necessary man in the organization.

These are some of the characteristics which can be deliberately aimed for in the new designs. Although they now seem utopian, the next few years may see substantial attainment of great portions of them.

Discussion

PRESENTED BY

R. W. KIRKLAND, Systems Application Engineer, Metal Rolling and Processing Engineering, Industrial Engineering Operation, General Electric Co., Schenectady, N. Y.

R. W. Kirkland: The author has very clearly described the frightening complexity of steel plant communications and accounting systems.

Most of us appreciate that this complexity is a natural and necessary thing since these systems have grown, little by little, as the plants have expanded. The automation of an entire system or a portion of it is difficult but not impossible, since the basic system structure is usually retained.

When a business machine is applied to one portion of an accounting system, the communications net probably remains unchanged. All that has been done is to substitute a machine operation for a similar manual operation making that portion of the system faster or more accurate.

However, the complex nature of these systems certainly shows that no portion of an integrated accounting system can be automated without considering the entire system. Certainly if one works on one portion at a time without considering how it speaks to the rest of the system one is apt to waste time and money changing machines and procedures to achieve compatibility.

In many cases the development and use of automatic data gathering and process machinery has resulted in an increased burden on the interplant communications system. This is true because these new systems make additional desirable information available, quickly and at low cost. Few systems planners can resist the urge to get the maximum output from each new installation. This can overload the next link in the accounting system.

Each item of information, derived or transmitted, should be forced to justify its existence.

There is need, as the author indicated, for considering the human operators as a part of any new automation system.

Recently, there was a computer application symposium to discuss case histories within our company. Of the case histories presented, all but two were unqualified successes. The two unsuccessful applications had failed because the planners had neglected the opinions, fears and training of the people who had to work with the machines. The habits, attitudes and abilities of the people who are to work with automation equipment must be considered.

This is particularly true of the new generation of on-line process control computers. Here mill operators, production machinery and mill accounting systems are tied together.

The mill operators must be encouraged to cooperate with automation systems.

This may well mean that the incentive pay plans should be changed when automatic systems are installed to make the operators want the system to do its best.

Process automation involving digital computers will require knowledge of plant communications and accounting as well as process control. ▲

Oil Mist Lubrication on anti-friction backup roll bearings

by C. W. SOUTHERINGTON

Chief Engineer, Dallas Div., Revere Copper and Brass, Inc., Chicago, Ill.

OIL mist lubrication was first used by Revere Copper and Brass, Inc., on a 9½ and 33 x 42-in. aluminum finishing mill installed at Revere's Baltimore Div. in 1953. This mill has anti-friction, tapered roller bearings on the work and backup rolls. The backup bearings are of the 4-row, tapered neck, balanced proportioned type.

Straight roller bearings were used on a 16 and 33 x 42-in. hot rundown mill, on copper, by Revere, as early as 1929. This mill was grease lubricated by an automatic cycling system. Even though it was a slow-speed mill (200 fpm) maintenance of the straight roller bearings and associated bronze cages was excessive. The long straight rollers were subject to spalling and breakage which usually damaged the races and cages. It is probable some of this experience led others in the industry to the design of the multi-row, straight bearing on similar applications. This mill was modernized in 1949 with precision oil-film bearings.

In 1951 a small, 2-high, 18 x 24-in. copper finishing mill was converted with 4-row, tapered roller bearings to the then conventional arrangement of straight-bore neck bearings. The cones fit loosely on the necks, designed with the bore of the cones approximately 0.0005 in. per in. of diameter larger than the roll neck. Lubrication slots were provided in the fillet rings, cone spacers and the face of the clamping ring so that the slight creepage of the cone on the neck could draw the lubricant through the slots into the clearance between the bearing bore and the neck OD. The bearings were lubricated by grease in a manual system. Again, this was a relatively slow mill. Bearing life was normal; however, the operating temperature made control of roll shape a major problem. This particular mill normally ran with the rolls hard together and the rolling load was insignificant, compared with no load on the drive.

Revere as a corporation has built its reputation as a supplier of quality products. Large amounts of nonferrous metals have been supplied to many high precision projects both in the military and general research developments over the years. As such it has been found necessary to reflect these specifications into the rolling mill bearings and maintenance. Precision rolling is being done on mills equipped with precision sleeve oil-film bearings and recirculating lubricating systems. However, most of these mills are on strip applications which operate with the rolls running and the metal is struck on the fly. It is found that frequent manipulation of the screwdown is necessary to compensate for

The injection of a constant amount of oil, at a maintained viscosity, into a bearing can eliminate the need for a circulating oil system and can reduce rolling oil-coolant contamination to a minimum, thus reducing both lubrication and over-all maintenance costs.

Figure 1 — When the bearing was disassembled for inspection the cups were very clean with no surface etching or wear.

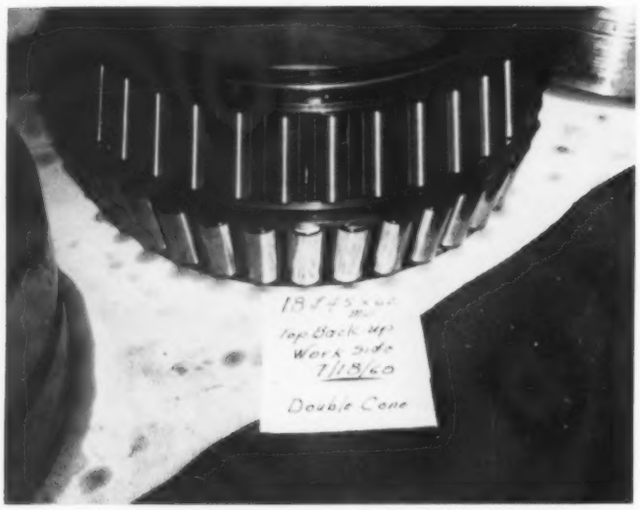


Figure 2 — A double cone from the rundown mill backup bearings shows no evidence of wear.

wide variation in metal gages as the mill is accelerated on those jobs where variable speed has been installed. Also, frequent stopping of the mills for the purpose of checking gages and other reasons results in loss of oil film and the associated gradual wiping of the journals.

The 9½ and 33 x 42-in. aluminum finishing mill installation was set up for rolling precision metal at 50 per cent of commercial tolerance or less. Oil mist lubrication with 4-row, tapered neck bearings was considered and installed primarily because of the arrangement offered, precision mounting of backup roll bearings, low breakaway power requirements, minimum variation in gage during the acceleration period and most important of all, the elimination of contamination of the rolling oil, which would result in staining on aluminum. The highly favorable success enjoyed with this installation led to the equipping of a new 18 and 45 x 62-in. rundown mill and a new 12 and 35 x 62-in. aluminum finishing mill at the Chicago plant, in 1955, with the same type of bearings and lubrication system. Management reasoned that close control of the gage in the rundown passes would result in improved gage control off of the finishing mills. The mills and bearings were liberally sized for the job to be done. Design of the 18 and 45 x 62-in. rundown mill is for approximately 4,000,000-lb separating force. The 45-in. backup rolls have 4-row, tapered roller tapered-bore, anti-friction bearings 29 15/16-in. ID by 40¾-in. OD by 32 in. long which have capacity for 6,219,000-lb separating force at 500 fpm or 5,059,000 lb at 1000 fpm. The separating-force rolling load is 2,000,000 lb and over on most alloys and in excess of 3,000,000 lb on some of the magnesium-bearing alloys.

Oil mist lubrication eliminates heat build-up due to churning of the lubricant in the bearings. The bearings operate comparatively cool. Shape control of the rolls is facilitated. Material gage from side to side can be held more accurately due to the greatly reduced temperature throughout the entire mill length. A combination of features effects this end result. The tight-fitting taper-bore cones eliminate the heat build-up formerly experienced with the straight bore bearings. Oil mist is conveyed to the bearing through condensating fittings with eight to ten psi air pressure. The pressure drop across these orifices results in a cooling of the air and condensation of the oil to liquid form. Conditions contributing to heat build-up in the bearing are, therefore, maintained at a favorable minimum.

Oil level is maintained in the bearings as high as the apex of the cups on the bottom of the bearing by the proper location of a vent fitting. Oil is, therefore, always available for the rollers. The design of the tapered roller bearings induces oil flow from the front face of the cone to the back face of the cone due to the centrifugal action of the roller and cage assembly about the shaft. The natural taper of the cup tends to make the oil flow toward the large end of the rollers and circulate through the holes provided for the purpose. This not only tends to assist in lubrication of the bearing, but also tends to pull any foreign particles or dirt through the bearing and remove it from the clearance between the rollers and the cage. This is an important advantage of mist lubrication.

The function of lubricants for tapered roller bearings is quite similar to that for any type of anti-friction or plain bearings in that they reduce friction, carry away heat, protect bearing surfaces from corrosion and contribute to seal efficiency in keeping foreign matter out of the bearings. In the case of the reduction of friction, it is obvious that the lightest-bodied oil will show the lowest bearing friction; however, extreme pressure additives aid in decreasing this friction for a given oil.

A multi-purpose gear lubricant, API Service GL4, with a viscosity of 1000 SSU at 100 F is being used in the bearings. This is a lubricant which was developed for the automotive industry primarily for use in synchromesh transmission drives. It has a rating of 35 at 600 rpm on the Timken load test machine.

There is a fallacy in believing that in order to assure the best lubrication for a bearing one should use the greatest amount. Too much or too heavy a lubricant, if incorrectly used, will cause an increase in temperature due to churning action of the bearing in the lubricant. This is usually followed by a lubricant leakage through the seal enclosure. In the case of grease, good lubrication depends on whether the bleeding ability of the oil under certain operating conditions will feed sufficient light oil to the bearing surfaces. Even though it may have good lubricating properties, it has that disad-

vantage in that it retains foreign particles within the bearing surfaces and acts as a lapping or grinding compound. Several bearings on a copper rundown mill were lost because of this difficulty. Oil mist lubrication introduces oil at a constant viscosity and maintains clean bearing surfaces. As evidence of this fact, see Figures 1 and 2. These photographs are not retouched and were taken during an inspection of the bearings primarily for the purpose of this article. These bearings have been in operation over five years and have been through one conflagration in that time. This cold rundown mill has rolled in excess of 175,000 tons of aluminum in gages ranging between 0.300 and 0.040 in. in widths from 36 to 54 in. with these bearings in the mill. Contrary to practice in some other mills, these bearings have not been alternated with another set for roll changes. In the more than five years' use of the three mills mentioned before, which have mist lubrication and taper neck, tapered roller bearings, no maintenance repairs have been necessary. It should be noted that in Figures 1 and 2 the surfaces of the operating zones of the cups and rollers are bright and clean. There is no etching of the surfaces, no foreign particles embedded and no evidence of wear.

Oil mist has other advantages, one of the most important of which is the elimination of contamination of rolling oil coolant. With oil mist lubrication bearing lubricant leakage is eliminated. It is known definitely that the rolling oil is not contaminated by the bearing lubricant because there is only a small volume of oil in the bearing. On a similar mill with oil-film bearings, there is continued trouble in keeping the lubricating system free of leaks. Repeated contamination necessitates periodic disposal and renewing of the entire system of rolling oil which amounts to in some cases 20,000 gal of oil. The mills which have mist-lubricated bearings have never had the rolling oil changed in their systems for this reason.

Maintenance of roll necks in good condition is a necessity to precision rolling, to assure accuracy in remounting bearings from roll to roll. The tight-fitting, taper neck bearings have eliminated the problem of fretting corrosion experienced with oil-film and other types of bearings. The necessity for neck lubrication has been eliminated. Figure 3 shows a neck of the 45 x 62-in. backup roll from which the bearings in Figures 1 and 2 were removed, no evidence of fretting corrosion, scuffing, or other condition of wear is apparent. This roll has been alternated in use with another set of rolls for a period of five years. It may also be noted that there is no galling in the area in which the chock seals ride on the neck fillet. The vent relief fitting on the outboard end of the bearing chock maintains internal pressure in the bearing. This pressure is sufficient to maintain the seals and exclude rolling oil from the internal parts of the chock. Internal air pressure of as much as five psi may be used to prevent rolling coolant lubricant contamination of the bearing lubricant.

Before going into the arrangement of the mist lubrication system, it should be of interest to illustrate the backup roll bearings used on the mills at Chicago with mist lubrication, along with the method used for mounting and maintenance provisions. Figure 4 shows the arrangement of the rollers within the bearing. The chock rifling shown at the bottom is actually at the

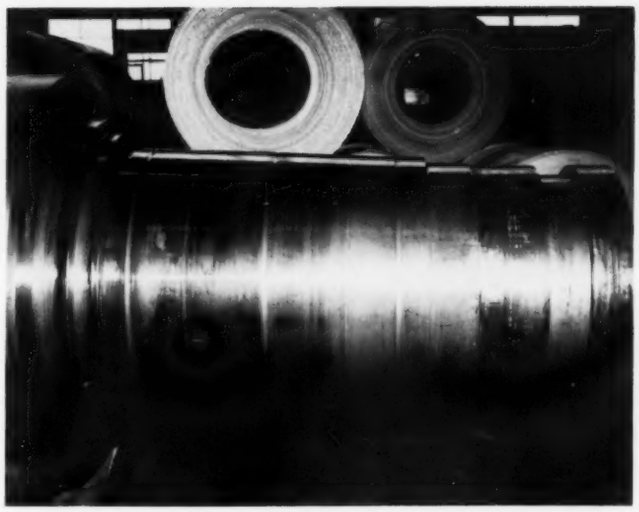
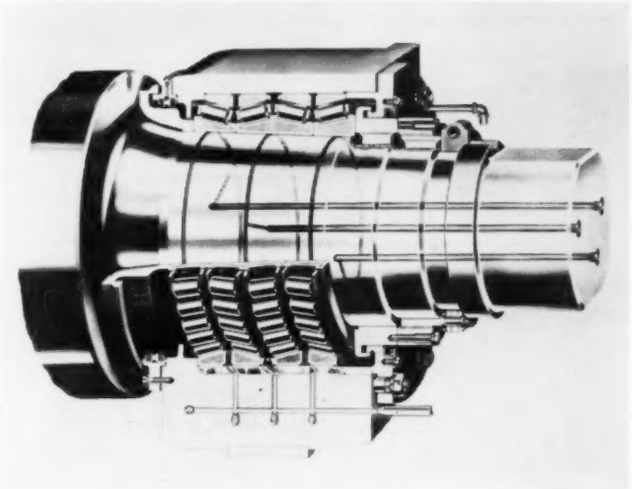


Figure 3 — The roll neck must be well maintained to assure the proper fitting of the bearing.

two and ten o'clock positions. It has been shown in this manner for pictorial purposes and further explanation follows. Fundamentally, the bearing is made up of two outer double races (cups) and two single-row inversely-tapered-bore cones at the end with one double-tapered bore cone mounted between them for the inner raceway. The inner races are clamped against a fillet ring which is applied with a press fit on the neck of the roll. All clearances within the bearing elements are properly established when the bearings are manufactured. The cones (inner race) are made with a taper of one in. per foot to press on the neck of the roll with a 0.010-in. interference fit. Mounting procedure is covered later in more detail. The prescribed interference fit of 0.010 in. is assured with a manufacturing tolerance of approximately 0.0005 in. Application of these bearings against the fillet stop is permitted due to the interchangeability of all bearings and the procedure that is used in properly establishing the fillet rings for all roll necks. The inner races are held in place by means of a follower sleeve and wide lock nut fitted over a solid threaded ring. The threaded ring and nut assembly is held in position by means of a hinged ring which can be readily applied or removed as necessary.

Figure 4 — The arrangement of the rollers within the chock and the rifling of the chock are illustrated.



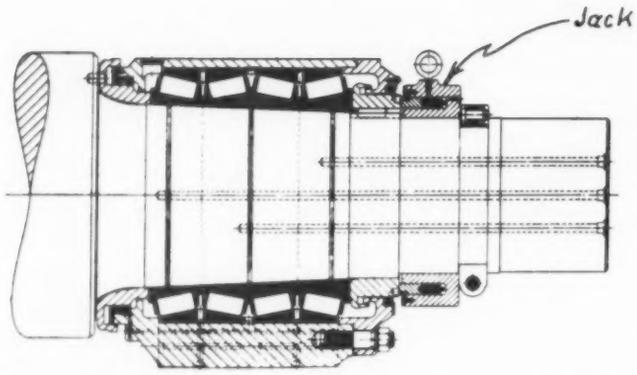


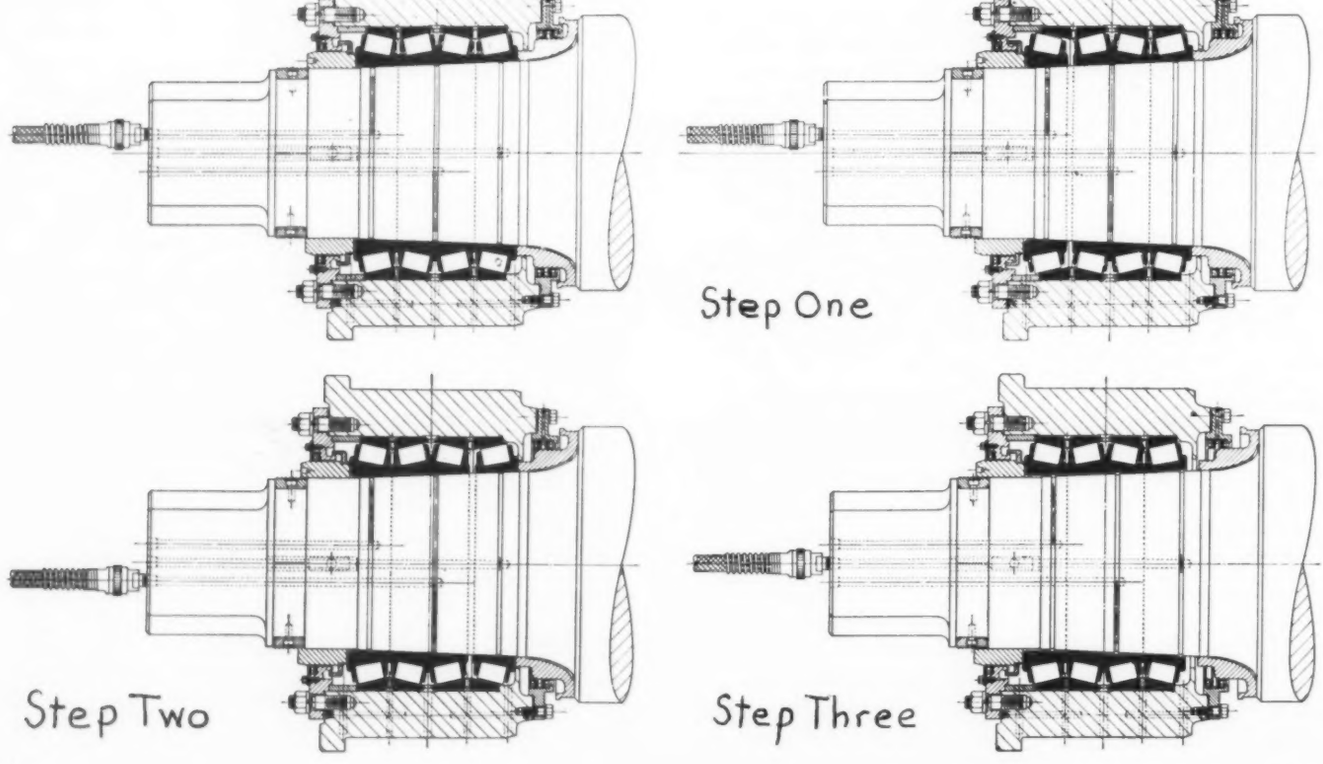
Figure 5 — The bearing must be pushed into position with a jack, because of the fit required.

The bearings on the operator's side of the mill are fixed in the chocks, and the chocks are held in the mill with keeper plates. Cups are clamped with the chock face plate, and the cones with the follower ring on the neck of the roll. The chocks as well as the bearings on the drive side of the mill are free to float. The drive-side bearing cups are mounted with 0.250-in. clearance in the chocks. This arrangement tends to practically eliminate thrust forces which might be imposed on the bearings due to expansion of the mill roll.

Bearings, chock and follower ring remain as an assembly while mounting on or removing from a roll neck. No major disassembly is required and either operation is a matter of only a few minutes. The roll necks are cleaned carefully with a solvent to make them absolutely dry before the chocks with bearings are put in place. The interference fit of the cones on the roll neck is pressed in place against the fillet ring with the annular jack. Figure 5 is a general arrangement of the jack in position for putting the bearing on. Approximately 5000 to 8000-psi hydraulic pressure from a shop jack is used to push the bearing in place. Removal of the bearing and chock assembly is done by means of oil injection through rifle-drilled holes in the roll neck to oil grooves located under the neutral section of each raceway on the roll neck. Figure 6 shows the progressive steps in which radial and axial pressure removes: step 1, the outboard cone; step 2, the center cone; and step 3, the inboard cone. Each cone progressively becomes free through the axial clearance between the cone face and the cup follower. The same shop hydraulic jack with 5000 to 8000 psi is used for this operation. Either operation is quick and trouble free. There has been no trouble or delays in making roll changes due to the assembly or removal methods.

A section through one side of the mill chock and bearing is shown in Figure 7. On the top half of each of the backup roll bearing chocks there is rifle-drilled two axial holes at the two and ten o'clock positions. Radial holes lining up with the center of each double cup and the spacer connect to each of the axially-bored holes to provide six entries into the bearing. Condensing fittings are used on the entry to the chock at the outside end of the axial hole. Basically, the condensing fitting is an orifice to effect a pressure drop and cause the mist to condense to liquid form. Therefore, oil in liquid form is conveyed through the radial holes to the bearing. The chocks are vented near the bottom with a vent fitting located in the chock end plate at a level which will maintain oil in the bearing up to the apex of the angle of the cups. This cannot be shown in the section because the vent fitting is at about the 5:30 position. The vent fitting performs a dual

Figure 6 — The bearing must be freed by use of hydraulic pressure.



function, maintaining both the oil level and a positive pressure inside the chock. It is also felt that there is an advantage to having the condensing fittings on the outside of the chock because they are accessible without having to dismantle the bearing. This arrangement has performed exceptionally well. Refinements in the arrangement of the rifling of the chock have been developed since the initial installation. The most notable changes are separate axial holes being used with each radial connection to the bearing and differences in the venting arrangement. On the next installation revisions to the entry arrangement will be incorporated. However, further study and consideration will have to be made before the venting arrangement is changed.

A schematic arrangement of the mist lubrication and piping as used on the 18 and 45 x 62-in. mill in Chicago is shown in Figure 8. All of the lubricator units were mounted on one railing of the screw-down platform. This was an ideal location for the units because it provided drainage of the lines away from the lubricators, kept piping to a minimum and is accessible as an entire system, on the mill, close to the points of use. It is recommended that the mist lines from the 1-gal lubricators not exceed 30 ft in length. No large piping is required; all lines are ½-in. size. Care in installation of the piping must be taken to be sure that lines are not trapped and that they drain away from the lubricator. Warning signals for low oil level or loss of air pressure can be seen or heard in the immediate working area of the mill. Of importance is the fact that it was not necessary to provide any special area or room for the installation of the lubrication system. No large heat exchangers with the associated services of steam and water were required. The lubricators do not have or need heaters because the mill is located in a heated building. However, on applications where the ambient temperature of the mill drops below 55 F, the units can be supplied with small, 115-volt, thermostatically-controlled electric heaters to maintain the correct oil viscosity for atomization.

In 1955 the cost of lubricating equipment for the 18 and 45 x 62-in. mill was less than $1500, exclusive of installation and piping but including hoses and special fittings. The simplicity of the installation reduces maintenance to a minimum and assures reliable operation. It has been found necessary to periodically clean the plug strainers located on the top of the lubricators. There are no pumps or other rotating equipment to maintain.

This system was sized to use 1-gal lubricators with capacity to handle 30 bearing in. One in. of diameter, through the center of the rollers, for each 2-row bearing section is equal to one bearing in. Therefore, each of the 4-row, 45-in. backup roll bearings which have approximately 30-in. diameter center circle for the rollers required two 1-gal lubricators.

The ratio of oil to air in the mist stream under normal operating conditions is from one to two drops of oil per cu ft of air. It is estimated that approximately 0.5 cfm of 80-psi air is used per lubricator. Records show that one barrel (55 gal) of oil was used between the 12 and 35 x 62-in. and 18 and 45 x 62-in. mills in one year. Due to variable conditions affecting the use of oil in recirculating systems, no attempt was made to compare operating costs. The contamination of the oil in a recirculating system one time in a year uses 600 or more gal of oil. The oil cost comparison with the mist system becomes insignificant, and there is always new oil. Electric power savings are significant in that some other types of systems require motors for pumps, centrifuges and large volume heating systems. Relative cost savings by others have been shown to be as high as 14 to 1. However, it is felt that the savings have exceeded even this study.

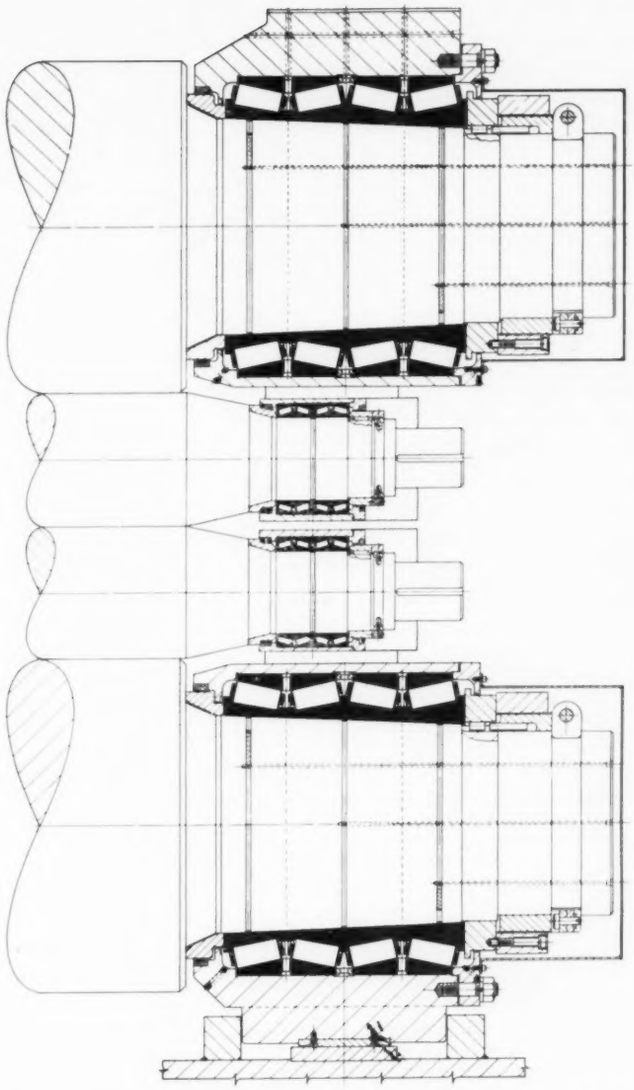


Figure 7 — A section through the roll bearings of the 18 and 45 x 62-in. mill is illustrated.

The application of oil mist lubrication on rolling mill bearings might be considered new or untried. Yet, there is a listing of 75 mill stands in the ferrous and nonferrous industries, located in this country, which have been equipped with oil mist lubrication on anti-friction bearings. Also considerable activity in connection with mist systems is reported in Europe and England. Further developments are being made in the field of mist lubrication with oils that range in viscosity from 1000 to 25,000 SSU at 100 F.

Revere has found pleasure in sharing its experience in the mist lubrication on anti-friction bearings, and hopes that the field may be broadened by further experiences and application.

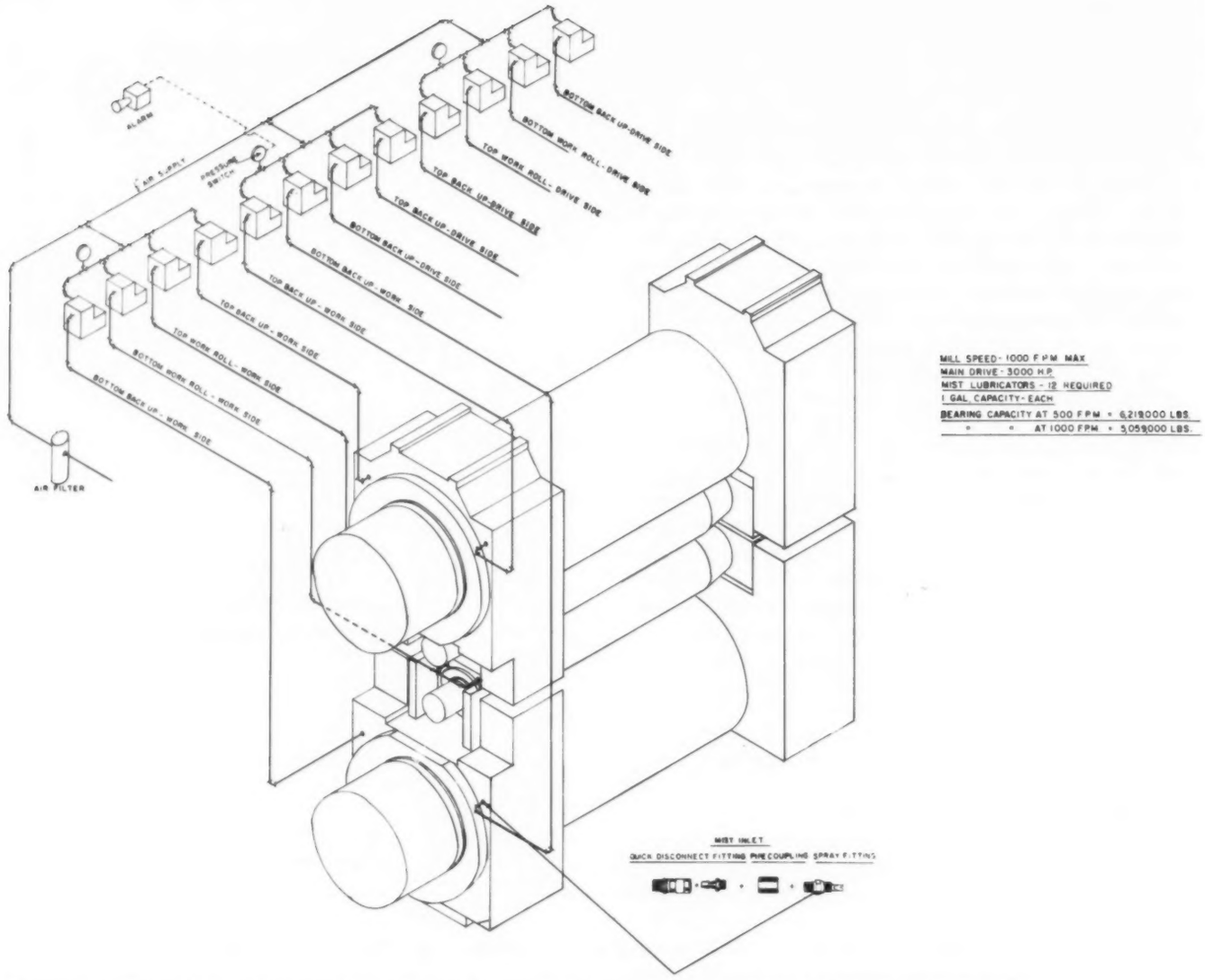


Figure 8 — The mist lubricator units and the piping require much less room than a circulating oil system.

Discussion

PRESENTED BY

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P. L. HAAGER, Assistant Chief Engineer, The Timken Roller Bearing Co., Canton, Ohio

RAY FRAZIER, SR. and T. M. MURPHY, Alemite Marketing Div., Stewart-Warner Corp., Chicago, Ill.

CHARLES S. MERCER, Manager Morgoil Bearing Dept., Morgan Construction Co., Worcester, Mass.

C. W. SOUTHERINGTON, Chief Engineer, Dallas Div., Revere Copper and Brass, Inc., Chicago, Ill.

J. J. Seaton: Since its infancy many years ago, the mist method of lubrication has grown in stature with each lubrication problem it has solved.

Realizing the value of this form of lubrication, the United States Steel Corp. has many mist installations within its plants. Most of these installations are similar to those being used in other areas, such as cold rolling, conveyors, fans, hot saws, etc.

However, a few words should be said about one application which is uncommon; an application of mist lubrication on pinion slipper brasses. Results obtained initially with this installation were poor. Restriction of the amount of lubricant, along with the low-viscosity oil required by the mist unit, was inadequate for good slipper brass lubrication. Realizing the need for higher viscosity oil, a heated air attachment was added to the mist unit. This allowed the use of a lubricant with a viscosity of approximately 3000 SSU at 100 F. The addition of a small plug, drilled with ten $\frac{5}{16}$-in. holes, placed directly behind the brass slippers permitted the tripling of the volume of oil. A change in seal design was also necessary. A thermal air-oil mist unit was installed approximately five months ago, and since its installation periodic checks have indicated little or no brass slipper wear. Since the mill is new there is no basic comparison on lubricant consumption. Basing consumption on mills that are now lubricating slippers with grease, there is a reduction of approximately 67 per cent in lubricant cost using oil mist in place of grease.

Finding the correct lubricating system for the application is the first step in good maintenance and operation. To further continue this policy of the most suitable and economical lubrication systems for the application intended, oil mist installations are increasing in number in the plants of United States Steel.

C. T. Lewis: The savings which may be obtained through the use of oil mist for lubrication of anti-friction backup roll bearings should be presented when methods for reducing over-all operating costs are being sought.

The author showed the lower costs involved in the amount of equipment required for the initial installation, the lower number of parts, the fewer controls in the system requiring maintenance and the successful lubrication of the bearings with a reduced lubricant consumption.

The author mentioned, "the application of oil mist lubrication on rolling mill bearings might be considered new or untried." This is partially true and is, in most cases, the result of the difficulties involved when trying to convince the operating and maintenance people responsible for uninterrupted production that the small quantities of lubricant supplied through a mist system can do as good a job as the volumes of lubricant applied by other methods.

There are definite advantages in: (1) the level of lubricant circulated within the bearing; (2) the additional assistance of the internal air pressure given to the seals to help prevent the entrance of outside contaminants; (3) the lower amount of lubricant consumed; and (4) the lower amount of contamination contributed to the mill rolling or cooling fluid.

Oil mist lubrication has considerably reduced neck scuffing on a mill using straight neck rolls and has added a polish to the shoulders of the individual rollers in the cone-roller assembly when compared to the surface appearances which previously existed when it was lubricated with grease containing portions of unavoidable contaminants.

Time and tonnage records which are being accumulated on oil mist lubricated anti-friction backup roll bearings should show an increase in the average bearing life.

P. L. Haager: Mist, fog and other air-charged arrangements have been successfully used in numerous types of industrial applications for many years. Each type of application must however be properly analyzed through the cooperative efforts of the mill or equipment builder, roller bearing manufacturer, the supplier of the lubrication system and the ultimate operator.

Failure to use certain simple precautions could result in misuse of the system with possible associated difficulties. Mist, fog and other related systems should not be accepted as a "cure-all" for lubrication problems. There are some applications where these arrangements might not be operative; therefore, the mist lubricating units should not merely be purchased and installed as so much hardware without obtaining the experience of the system supplier and the bearing manufacturer.

The author mentioned that mist systems had been erroneously considered as new and untried by many rolling mill operators, and he referred to a listing of some 75 mill stands which use mist in connection with tapered roller bearings in both ferrous and nonferrous mills in the U. S. A recent study shows that there are at least 113 mill stands in which air tapered roller bearings are lubricated with oil mist or its equivalent. Additional installations are being made on many new mills presently under construction, and there are constant requests for data in connection with changeovers from grease to mist on existing mills.

With regard to the study previously mentioned: 32 per cent of the 113 mill stands recorded (36 mill stands) are on ferrous rolling with 17 of these 36 mills using mist on both the backup and the work roll bearings; the 19 mills remaining use mist on the work roll bearings only.

Of the balance of 68 per cent or 77 mill stands rolling nonferrous materials: 36 of these 77 stands are hot mills; 16 are cold reduction mills and the remaining 25 mill stands using mist are foil mills. In the case of these 36 mill stands on nonferrous hot mills, 21 stands use mist on both the backup and work roll bearings while the other 15 use mist on the work roll bearings only.

In the case of the 16 nonferrous cold reduction mills, seven use mist on both the backup and the work roll bearings, three mills use mist on the backup bearings only and the six remaining use mist on the work roll bearings only.

The 25 foil mills mentioned previously use mist on both the backup roll and the work roll bearings.

From this summary it is obvious that the nonferrous mill operators have applied mist lubrication to many more mills than is the case with the ferrous mill operators. Moreover, one operator is testing mist in connection with lubrication of the work roll bearings of a continuous hot mill.

The men in the ferrous rolling activity who have not examined this matter carefully should check on the history of some of the ferrous rolling mills which have used mist successfully, for practically the same period of time as those in the nonferrous industry.

The use of mist on tapered roller bearings on both backup and work rolls is no longer of an experimental nature. The possible extension of the use of mist systems on the bearings of ferrous hot strip mills obviously depends upon the proper evaluation of operational problems, bearing mounting designs and use of properly designed closures to exclude water and scale from the bearing chocks. However, the most important requirement is the determination of the rolling mill personnel to investigate its possibilities and actually prove or disprove its advantages.

There are a few design features which should be provided to assure a satisfactory installation. These are directly related to the locations of entrance and exhaust holes in the mill chocks, the type and control of the oil used, the type of nozzle and a few basic instructions by the lubricating device builder. The bearing manufacturers and the mist or fog system suppliers are prepared to discuss details with any mill builder or operator who seeks such information. There are still some differences in opinion on the number and location of mist inlets for various sizes of bearings on different mills, but certainly general field experiences will soon neutralize these slight differences in opinion.

There are apparently no major differences in the cold rolling of ferrous vs nonferrous products which would create problems in one type of mill and not in the other.

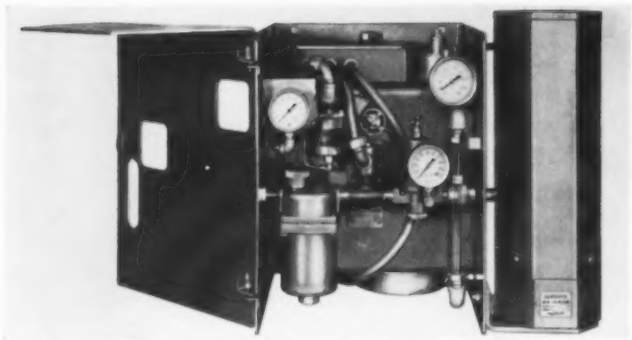


Figure 9 — Mist units can be equipped with heaters to permit usage of high-viscosity oils.

It will be quite interesting to note this lubrication system trend in the future. It is believed that the problems of material staining, rolling oil contamination and high lubrication and maintenance costs related to other systems and to other types of bearings will be the future guide and the basis for providing quality products at lower costs.

Ray Frazier, Sr. and T. M. Murphy: The author has, with supporting evidence, clearly and minutely described the merits of the combination of anti-friction bearings and oil mist lubrication for rolling mill operations, stressing the accrued advantages: The rolling of precision metal at 50 per cent commercial tolerance or less is possible.

There are low break-away power requirements which result in minimum variation in gage during the acceleration period.

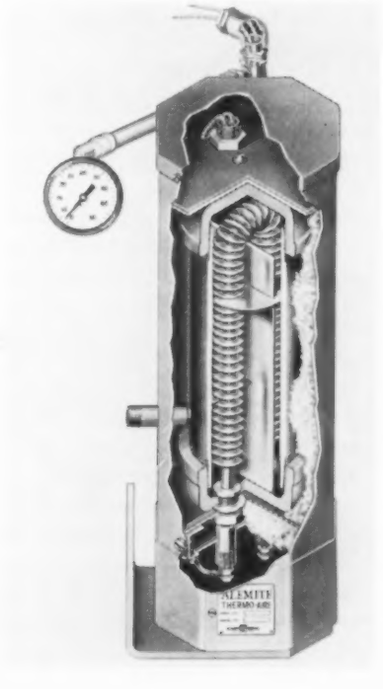
Heat build-up is eliminated reducing temperature in the bearings and throughout the mill length resulting in more accurate shape and gage control

The oil mist method of lubrication materially assists in keeping foreign particles or dirt from entering the bearing or collecting in the clearance between the rollers and the cage.

Oil mist lubrication introduces new, clean oil of constant viscosity and maintains the bearing surfaces clean without contaminating the rolling oils or staining the rolled product.

Also, the author points out the extended maintenance free bearing life that has been attained. After five years, service examination of the bearings shows the cups and rollers to be bright and clean. There is no etching of the surfaces, no foreign particles embedded and no evidence of wear.

Figure 10 — The heater is thermostatically controlled to keep the air temperature at a set level.



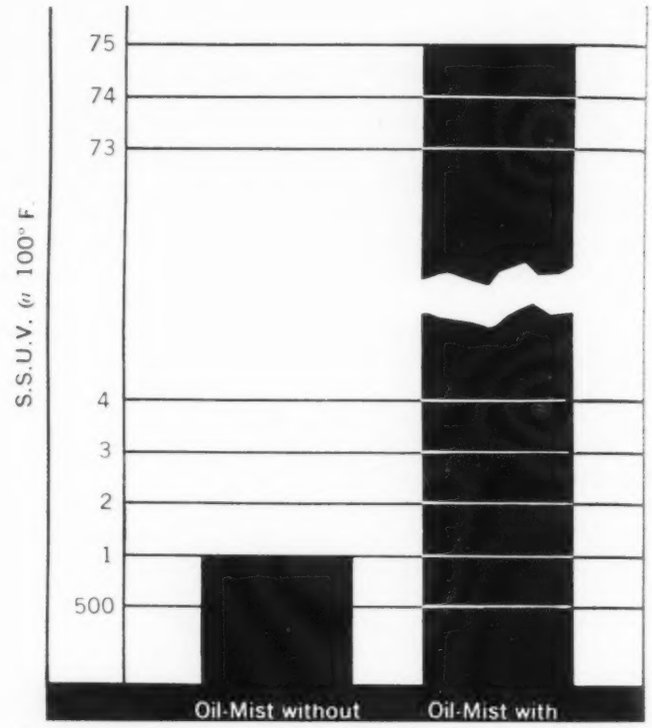
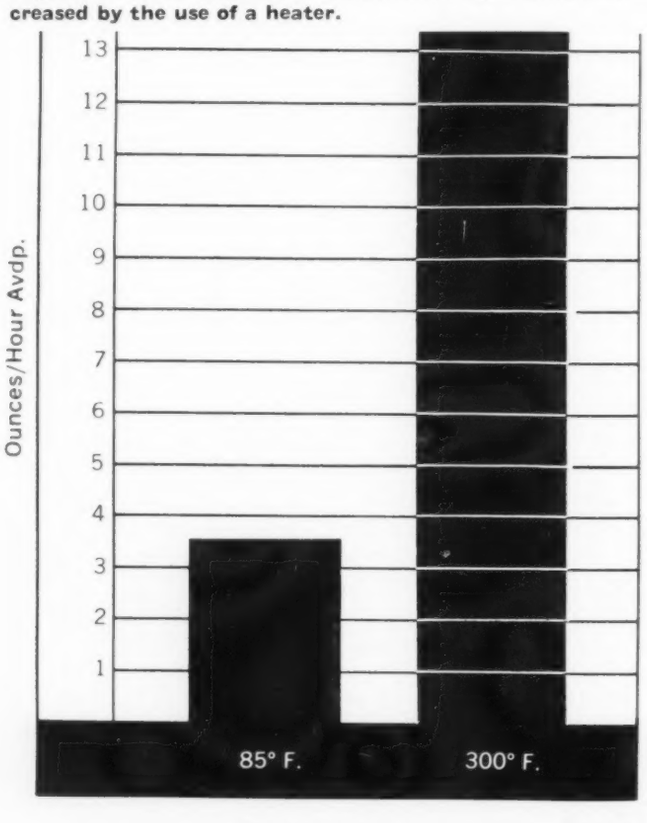
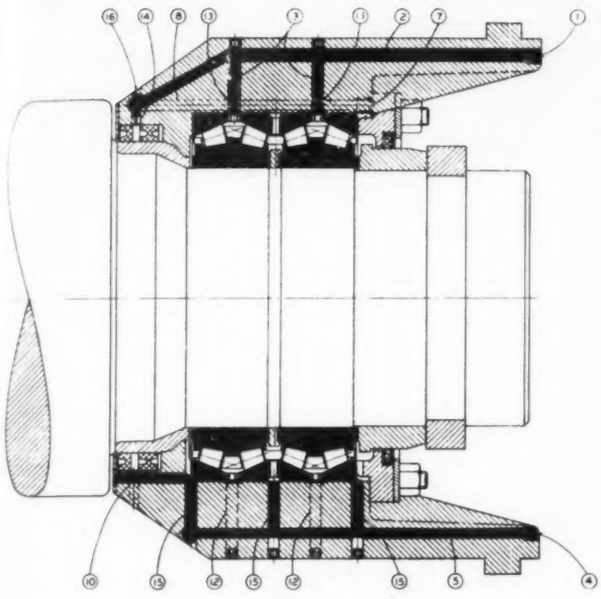


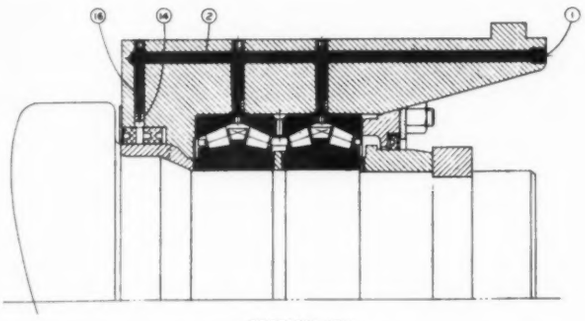
Figure 11 — The viscosity range of oils that can be misted is increased greatly by the use of air heaters.

Figure 12 — The amount of oil delivered by a unit is increased by the use of a heater.

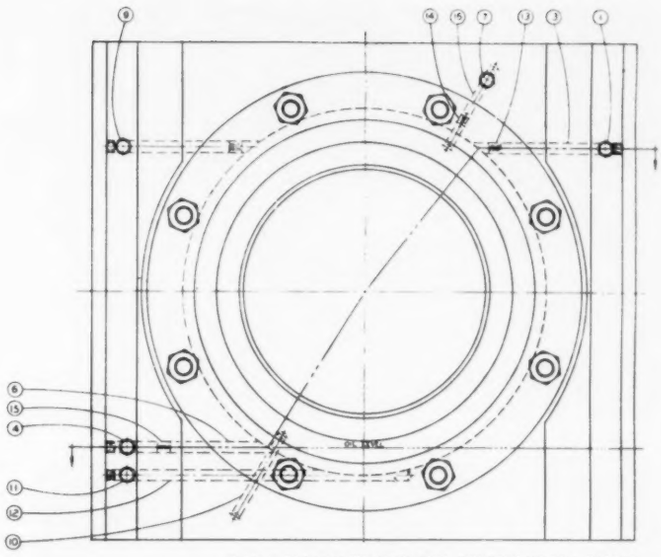




SECTION "A"



SECTION "B"



TYPICAL END VIEW FOR WORK ROLL AND BACK UP ROLL CHOCKS

Provide lubricant entries at location 1 for bearing & 7 for seal. Drill horizontal oil holes 3 joining cup spacers with axial hole 2. Lubricate inner seal through entry 7, axial hole 8, & radial hole 16. Spray fitting plugs to be installed in lubricant entry holes at location 13 & 14.

Provide vent holes at locations 4 & 10. Drill horizontal air vent holes 6 joining end cups & center double cup with axial hole 5. Vent inner seal through radial hole 10. Vent plugs to be installed in vent holes at locations 15. Horizontal vent holes 6 to be drilled on oil level line.

Provide drain hole at location 11. Drill horizontal drain holes 12 joining cup spacers with axial drain hole.

Sight level may be installed between holes 4 & 11 to check oil level.

Provide additional lubricant entry at location 9 if needed.

Section "B" shows one lubricant entry to serve both bearing & seal. This is desirable if chock design permits this drilling.

Figure 13 — A method of chock modification to permit the use of oil mist lubrication is illustrated.

Costs, in these times when it is most imperative that they be controlled, have been reduced in the following areas: product rejection due to off gage or staining; maintenance and operating life of bearings; use of and maintenance of lubricating and rolling oils; reduced installation costs and maintenance of oil mist systems.

Until now, oil mist methods of lubricant application were more or less confined to those bearings and gears that required only small amounts of oil and were so loaded that their required lubrication could successfully be sustained with oils up to 1000-SSU viscosity at 100 F.

However, the years 1959 and 1960 have been significant ones in the oil mist method of lubricant application. Greater volumes of heavier oils may now be misted and conveyed in an air stream. Significantly heavier loaded bearings and gears have been successfully lubricated.

Down through the years since the inception of the oil mist principle of air-borne lubrication for multiple bearings, various attempts were made to develop an oil mist unit that would permit the misting of heavier oils. Oils were even boiled in the units with no usable success. In 1959 it was discovered that if the air entering the oil mist unit was heated to approximately 275 to 300 F immediately prior to its entry into the misting head of the oil mist unit, lubricating oils of almost any viscosity could be put into the mist state for air-borne conveyance to the points to be lubricated.

Figure 9 shows the oil mist unit equipped with an air heater. Air at normal temperature enters the strainer and water separator where moisture is removed. It passes through the solenoid-controlled air valve into the air pressure regulator and into the air heater where the temperature can be thermostatically controlled within the range from 100 to 300 F. It passes from the heater to the misting head where the heavy oils are converted to the mist state and are conveyed in the air stream. Because of rapid expansion of the air-oil mixture into the tank reservoir and transmission lines the temperature of the air-oil mixture is significantly dropped immediately without any impairment of the oil carrying capabilities of the air.

Figure 10 shows the basic design of the air heater. It has two thermostat controls, one controls the set temperature and the other controls a warning device that gives a signal if for any reason the temperature falls below a minimum level.

Figure 11 shows the viscosity range of lubricants that have been misted by oil mist units with and without an air heater. The column on the left shows 1000 SSU at 100 F oil as the maximum viscosity that can be handled without the air heater. The column on the right shows that oils with viscosities up to 75,000 SSU at 100 F have been successfully misted. In the general com-

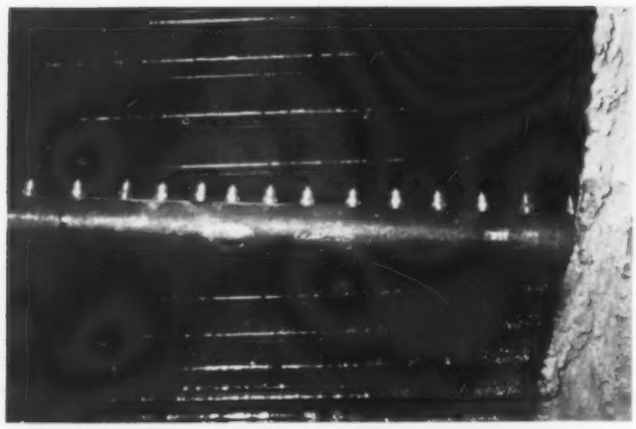


Figure 14 — High-viscosity gear oils can be misted.

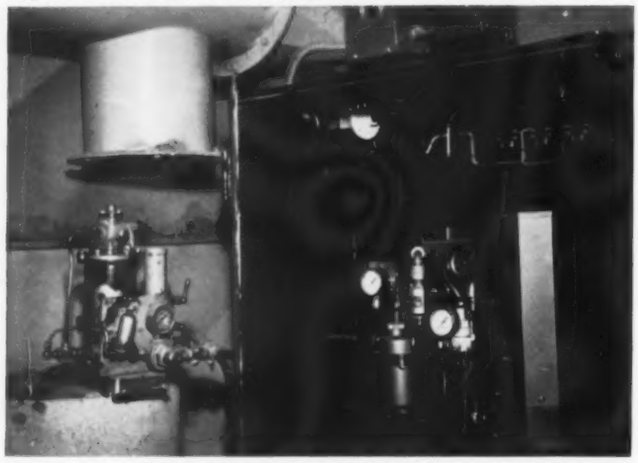


Figure 15 — The unit can be directly connected to a drum to assure a constant oil supply for a prolonged period.

mercial recommendations of the use of this unit the maximum viscosities of lubricants recommended have arbitrarily been reduced to 25,000 SSU at 100 F oils as it is believed that oils up to this viscosity will cope with 90 per cent of the lubrication problems, and that this arbitrarily reduced recommendation and would retard the inexperienced salesmen and users from trying to attain the ultimate limits where more care and caution must be exercised.

Figure 12 shows a comparison of the oil mist output of a single 500-SSU oil with and without the heater.

A little more than three times as much oil in the light oil range is delivered with the heater as is delivered without the heater.

Figure 13 shows a method of application that has been undergoing successful trials during the past few months. The main points of this method are:

Mist control fittings are embedded in the chock at the critical bearing points.

The main line of the mist system passes into the chock at one or, at the most, two points.

Controlled venting, oil level and/or drainage are provided for.

The installations to date have so far been completely successful. They have been applied to the work roll bearings on a hot strip mill in the steel industry and on the backup roll bearing on a hot mill in the aluminum industry. Expansions of the installations are in process. The lubricant being applied to both types of bearings is 2500 SSU at 100 F oil. Neither moisture nor other deleterious material has entered the bearings.

Figure 14 shows the continuous application of relatively heavy gear compound to a 15-ft diameter, 26-in. face bull gear and pinion in the cement industry. Two additional gears, 15 ft in diameter with 8-in. faces, are lubricated from the same heater-equipped oil mist unit. The three gear sets are spread over a distance of 150 ft. Lubricant consumption is approximately three pints total over 24 hr.

Figure 15 shows how the oil level in the oil mist unit may be automatically maintained from a refinery filled drum. If the drum is emptied and the oil mist unit is at its minimum level a warning signal is sounded, indicating that emergency reserve oil is being consumed and that it will have to be replenished soon.

Charles S. Mercer: The author's article is an excellent presentation of one of the schemes to eliminate staining of aluminum strip from grease and oil contamination of the roll coolant. Many of the bearings operating in the aluminum industry, where loads are generally low and maintenance usually good, are of a design that would now be considered antique. Modern oil-film bearing sealing arrangements are entirely different and are operating with marked success.

To minimize the problem on oil-film bearings of old design, nonstaining lubricants are currently being tested. Preliminary results are very encouraging.

The author's praise of tight-fitting tapered neck bearings with hydraulic removal is interesting. This type of mounting has some appeal for those mills where the rolls are changed infrequently. A similar design in an oil-film bearing is giving satisfactory service in a reversing cold mill in the steel industry, and this design can be offered whenever desirable. Of course, the sleeve that is hydraulically mounted is one piece with only one drilled hole for hydraulic removal and no separate precision spacing rings are required. The neck is not lubricated.

C. W. Southerington: It has been said that oil mist is a scheme to eliminate staining of aluminum strip from grease and oil contamination of the roll coolant. Primarily, oil mist must be recognized as a method of lubricating anti-friction bearings which has been proved in successful applications on many mills in the ferrous and nonferrous industries, proved reliable in operation in addition to eliminating contamination of roll coolants and reducing operating costs to a small fraction of the cost of lubrication by other methods.

The loads on aluminum are not light. It may be true that many of the bearings in the aluminum industry are of a design that would now be considered antique. This would hold for any industry which has existed for a period of time. On the other hand, some of the most modern bearing applications have been made in the aluminum industry. Actual bearing overloads are more constant and usually considered just as severe, if not greater, than those encountered in ferrous rolling. In the design of any rolling mill, rolls are sized for the anticipated load to be carried and bearings proportioned to carry this load.

The question of tight-fitting, tapered neck bearings was originally approached with much investigation prior to placing the first application on contract with the mill builders. On the seven mills now so equipped, there has been no difficulty with this feature. Scuffing and fretting corrosion of the roll necks has been eliminated. ▲

ELECTROCHEMISTRY IN THE STEEL INDUSTRY

by E. E. VONADA

Product and Application Specialist, Reliance Electric and Engineering Co., Cleveland, Ohio

. . . . the line speeds, production rates and quality controls of electrolytic pickling and plating processes have advanced greatly in recent years. However, these processes are still regulated by the fundamental relationships discovered in the early 1800's . . . .

BY definition, electrochemistry deals with the relations between, and the mutual transformation of, chemical and electrical energy. It began with the development of Volta's cell about 1800. Since that time, extensive studies have been made on the voltage relationship between gases, metals and chemical solutions. In nearly all the investigations, electrical measuring techniques and energy-measuring media have been employed to determine the relative value of the project.

A brief look should be taken at some of the exploration that has gone on in the last century and a half. Continuously, metal-to-metal junction potentials have been intriguing to the electro chemist, the metallurgist and the physical chemist. During the first half of the 19th century, the basic elements of thermocouples, thermoelectricity and semi-conductors were discovered, but it took nearly 100 years to put them into practical use. In industry today, thermocouples and temperature control fit together hand in glove.

Semi-conductors have evolved from copper oxide, through selenium and germanium, to silicon. This development moved rapidly into a tri-junction phenomenon with the advent of the silicon-controlled rectifier. As for thermoelectricity, thermoelectric generators are being used extensively in the satellite programs.

However, not all the uses of these developments are as glamorous as the ones mentioned. For instance, consider the electrolytic processes widely used on strip steel processing lines. These processes involve electrolytic pickling, cleaning and coating of carbon steels; and the descaling and controlled oxidation of stainless steels.

Another very common use of electrochemistry is in the field of batteries. However, for the purposes of this article, only the electrolytic processes employed with strip steel lines are considered, and the following points are stressed:

1. Something about the basic processes must be known in order to comprehend what is desirable in over-all system control.

2. It is desirable to formulate a common ground of understanding that may do away with the questions and misinterpretations that have arisen in the past.

Some remarks may be controversial, and it is hoped that they stimulate thinking on the subject. Right now a review of the principles of electrolysis involved in pickling, cleaning, coating and descaling is in order.

Assuming that a source of relatively low-voltage, high-current d-c power is available, the current is conducted by two classes of conductors:

1. Metallic or electronic conductors, which comprise substances in which the current consists of a motion of electrons from one atom to another. For best efficiency, the lowest practical resistance metal should be used.

2. Electrolytic or ionic conductors, which comprise solutions in which the current consists of a motion of ions; the electrons remaining on their respective ions throughout the conduction. In ionic conduction, matter is transferred. Electrolytic or ionic conductors are typified by solutions of acid, bases, salts, fused salts and hot gases. Electrolytic or ionic conduction always produces a chemical change.

The electrolyte, the substance in which this ionic transfer takes place, is shown in Figure 1. It receives electric current through an electrode called an anode, and leaves it through another called a cathode. The anode is positively charged, and the cathode is negative. The part of the electrolyte near the anode is called the anolyte; the part near the cathode is called the catholyte.

In electrolytic pickling or cleaning processes when current flows through the electrolyte the following takes place: At the anode, electrons are surrendered to the external circuit, and oxygen is formed on the surface of the electrode; this is called an oxidation process. At the cathode, electrons are obtained from the external circuit, producing hydrogen on the electrode surface; this is called a reduction process.

Now, the three basic forms of electrolytic cells employed in the common electrolytic processes in the steel industry today should be reviewed.

Figure 1, cell No. 1, is the type commonly used for electrolytic cleaning of carbon steel, and for electrolytic

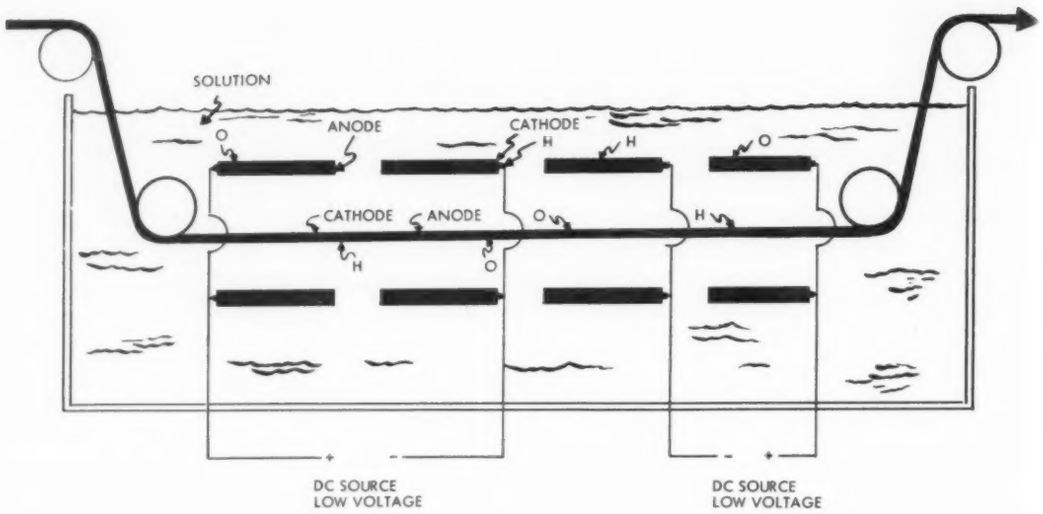


Figure 1 — The layout of an electrolytic cell is illustrated with the basic items identified.

deoxidation or controlled oxidation of stainless steel. The electrolytic process is through the use of electrodes exclusively; there is no metallic conduction through the strip. In this example, from left to right the first pair of electrodes are positively charged and are therefore termed anodes. The strip is negative in relation to the anodes and becomes a cathode. The second pair of electrodes are charged negatively, therefore becoming cathodes, while the strip is a positively charged anode. The next pair of electrodes are negative, and the last pair on the right are positive. In this last pass between the positively charged anodes, the strip is a cathode and is developing hydrogen gas on its surface. No uniform oxide coating is developed on the strip surface; the result is that over a period of storage time nonuniform oxidation will develop on the surface which will tend toward nonuniform metal deposition as the strip is plated.

Figure 2 shows the same cell under correct polarity for satisfactory electrolytic cleaning. The first pair of electrodes on the left are now charged negatively, becoming cathodes. The second pair are positively charged and are now anodes. The third pair are positively charged anodes, and the last pair on the right are cathodes. Thus, as the strip passes between the last pair of electrodes, it is itself an anode and the nascent oxygen liberated produces a uniform oxide coating.

Figure 3 is a simplified drawing of cell No. 2 type. This arrangement is typical of those most commonly employed for cleaning, pickling and coating, and it can be called the "workhorse" of the electrolytic cells now in use. The polarity shown is as used for plating. A negative charge is put into the entry and delivery conduction rolls, while the electrodes are positively charged.

Figure 4 is yet another cell, cell No. 3 which is typical of those used for coating in the halogen process. As in cell No. 2, the strip, which has already been cleaned, first passes over a negatively charged conduction roll, and "floats" on top of the plating solution. A positive electrode, or anode, is submerged in the solution. The strip then proceeds over another negatively charged conduction roll, and again floats over the surface of a second cell with an anode immersed in the solution.

As previously stated, cell No. 2 can be used for electrolytic cleaning, pickling or for coating. Proper application of generators or rectifiers and polarity reversing switches can provide the desired combinations of anodic and cathodic cleaning and pickling. The common item in these two cells is the fact that the strip itself becomes one of the electrodes, since one of the power source polarities is introduced to the strip by the use of conduction rolls. Greater operating efficiency can be expected from this type of construction, since one of the electrolyte resistance paths has been eliminated.

These cells make use of the basic electrolysis process

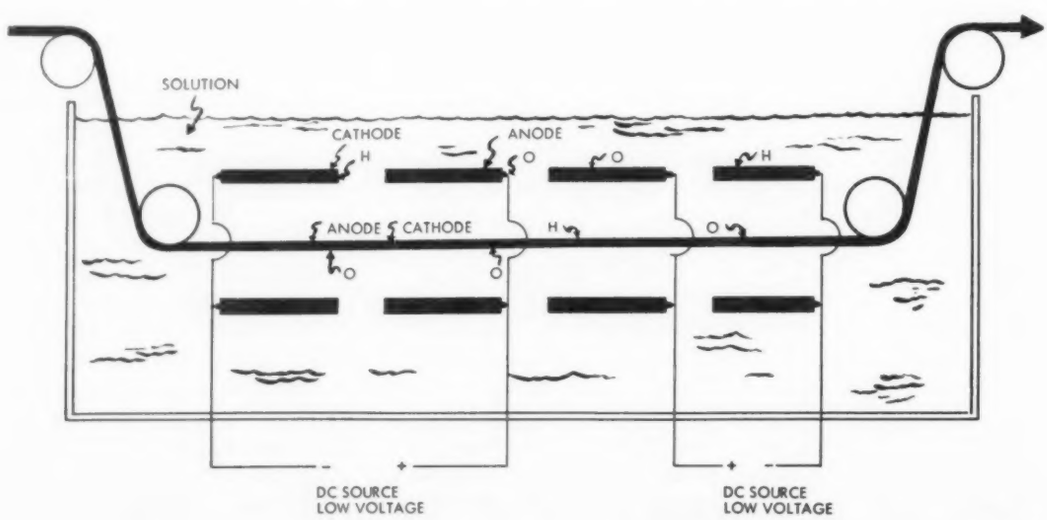


Figure 2 — The polarity of the cell is reversed by reversing the leads from the d-c sources.

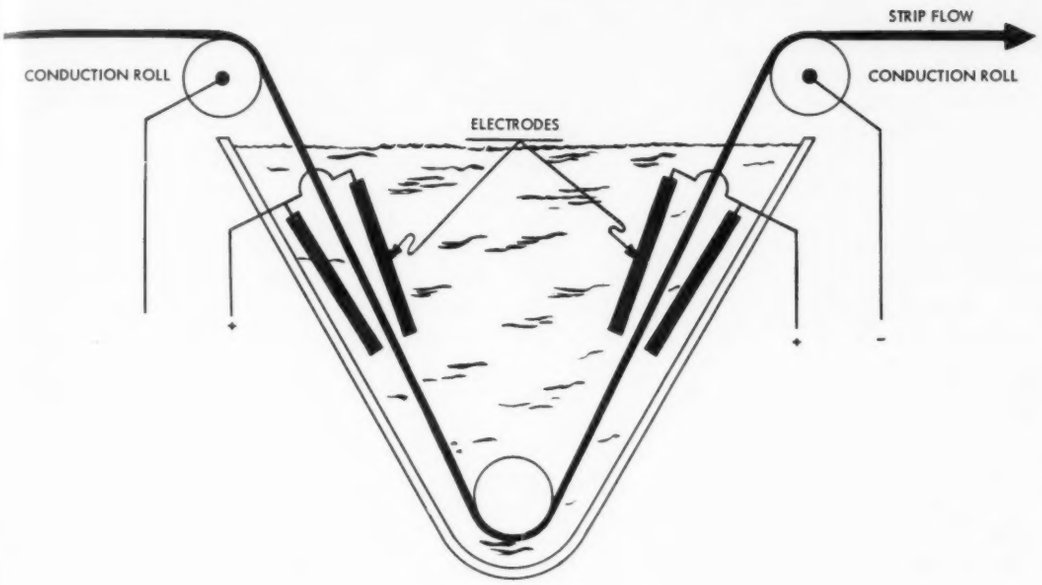


Figure 3 — The use of conduction rolls eliminates one resistance path from the circuit.

and show how it is applied, but several basic relationships which explain the electrolytic phenomena should be stated for clarity.

Back in 1833, Michael Faraday formulated two laws of electrolysis, which are in use today. His first law states: "The quantities of substances set free at the electrodes are directly proportional to the quantity of electricity which passes through the solution."

The second law is: "The same quantity of electricity sets free the same number of equivalents of substance at the electrodes."

The electrochemical equivalent of an element is the number of grams of the element which are set free by the passage of one coulomb of electricity through an electrolytic conductor.

From Faraday's laws, it has been established that one Faraday equals 96,500 coulombs, which equals 26.8 amp-hr.

National standards of the amp and the normal Weston cell voltage are determined by Silver Coulometers and Faraday's laws.

Current density is the current strength per unit of cross-sectional area. Conventionally, current densities are commonly expressed as amp per sq ft at one of the electrodes.

Conductance is the reciprocal of resistance, and the unit is the mho, or reciprocal ohm. The specific conductance is the conductance of a material in the form of a cube, the current passing from one face to an opposite one.

Polarization in an electrolytic process is a potential generated at the electrodes, having a polarity which opposes current flow. This counter voltage is generated at the electrodes, having a polarity which opposes current flow. This counter voltage is generated on the electrode surface, with a resultant formation of gas. A polarization potential exists for each combination of electrode material and electrolyte. Current flows when the applied potential exceeds the counter potential.

The item that is felt to be most important is conductance. Assume that cell No. 1 (Figure 2) is an electrolytic cleaning line for cold rolled strip steel in the tin-plate gage range. Electrolysis is normally carried out in a basic solution, trisodium phosphate plus sodium hydroxide additive.

Copious evolution of gas on the strip surface is necessary in order to dislodge grease from the porous grain boundaries. Effective cleaning depends upon the amp-sec exposure time of each unit of strip surface area under the electrodes. Efficiency demands that current flowing between electrodes be conducted as much as practicable through the strip.

In the complete cell, Ohm's law demands that the greatest current will flow through the lowest resistance path. It must be recognized that the solution can conduct, but that it has a variable resistance depending upon the concentration, temperature and chemicals employed.

In this cell, there are, as parallel paths, the tank, the electrolyte and the strip. Keeping Ohm's law in mind, there is an essential requirement to provide for uniform current distribution between the electrodes and the strip.

In cell No. 2 (Figure 3) it should be noticed that the electrodes have been tapered.

This tapering or "toeing-in" of the electrodes is necessary to provide a more uniform resistance path

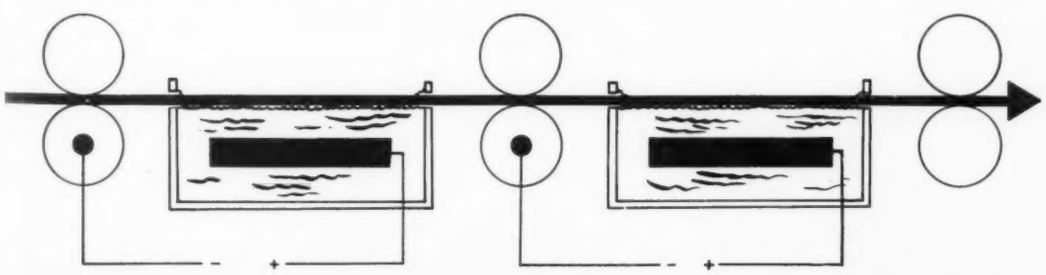


Figure 4 — The halogen process makes use of a cell in which the strip floats on top of the plating solution.

between the electrode and strip when all current is introduced at the top of the electrode. Steel company research, mechanical and electrical groups and machinery builders have combined forces to develop electrodes and mechanical adjusting media to obtain cross-sectional current uniformity in all the cells discussed. In tinplate production, all producers have done an excellent job in obtaining optimum quality plate at maximum efficiency. Much research has gone into obtaining greater solution throwing power range. Solution inhibitors have been developed which introduce mobility barriers to obtain more desirable fine-grain tin deposits and to reduce "treeing" tendencies. This research covers the stannous sulphate acid process, the sodium stannate basic process and the stannous chloride halogen process.

From an electrical standpoint, there has been an attempt to influence the application of individual electrode power supplies so that the cell constant variables can be easily detected, and to provide a simple electrical means for adjusting for desired results, rather than depending upon mechanical electrode adjustment alone. In addition, the use of transducers for individual cell current indication and as a relatively high wattage supply for totalizing, indicating, recording and controling has been advocated.

It is relatively easy to determine stray losses in a cell of this type. The losses might be between electrodes through the solution, and in parallel through the solution to the sides of the tank. To check them, the strip should be removed and the voltage vs current characteristics (cell constant) of the tank plotted. If the losses are more than 10 to 15 per cent of the total power applied, electrode modification, use of tank insulation or both should be considered.

Refer again to cell No. 1 (Figure 2) keeping in mind that hydrogen is poisonous to carbon steel, and that care should be taken to minimize steel exposure to hydrogen. In this type of cell, hydrogen evolution on the strip surface is inevitable. But polarities can be arranged as shown, so that the final exposure is an oxidizing one. In this cell, oxygen gas is evolved from the electrodes to the left, and hydrogen gas from the strip surface between them. Since the strip is anodic to the electrodes on the extreme right, oxygen will be liberated on the strip surface and hydrogen from the electrode surfaces. Oxygen will generate a uniform oxide coating on the strip surface. This oxide coating will help eliminate the formation of complex oxides on the strip surfaces between the cleaning and annealing operation.

This arrangement of electrode polarity, with the last set of electrodes negative, is essential to the proper preparation of strip for plating. Any other arrangement will invite excessive entrapment of hydrogen in the grain boundaries and inferior coating.

Also, it is recognized that it is necessary to reverse the electrode polarity every so often in order to minimize impurity build-up on the cathodic electrodes. One must go back about 20 years to see how this has come about. At that time, an electrolytic cleaning tank had been in operation for about two years. An increase in voltage of the generators would not produce increased current. An investigation was conducted to find out why. A qualitative chemical analysis of scrapings from the electrodes disclosed the presence of at least 75 per cent of the elements. The electrodes were replaced, and their polarity was reversed once a week after that. Electrode resistance build-up was no longer a problem.

Today, this practice is still followed, but on a different schedule. Polarities are reversed with each coil change, or on a running time basis. This is production suicide. By reversing the polarity of the final electrodes, supposedly for the sake of eliminating build-up on the electrodes and providing a better product, an inferior product is actually being produced. In normal production, the final electrodes in the cleaning process must be negative in order to give the strip a properly oxidized surface.

Certainly, polarity reversal is the easiest way to do away with build-up on the electrodes, but two 2-hour periods of reverse polarity per week will keep the grids clean. These periods could be during regularly scheduled nonproductive line shutdowns.

The benefits to be gained from strip pre-electrolytic cleaning immediately prior to electrolytic coating have often been questioned. This cleaning is certainly another source of potential hydrogen pickup and entrapment in the steel. It seems that the electrolytic and chemical cleaning action of the plating bath itself would adequately take care of the minute and rare contact between petroleum oil and the strip surface.

For the best electrolytic pickling prior to coating, current densities in the order of 100 to 150 amp-sec should be employed. Here again, hydrogen exposure should be minimized; the strip should leave the pickling area in the oxidized state. A uniform oxide coating will be quickly dispersed in the plating cell.

Why is more care not taken in the control of the pickling solution? It would certainly be desirable to keep the solution free of ferric iron by filtering, and of excessive ferrous iron by more frequent dumping and replacement of the solution with a fresh supply. The results are obvious: better, more positive pickling without ferrous iron "plating" or foreign elements "hitchhiking."

Some years ago, the opportunity to investigate a more rapid method of measuring tin-plate corrosion resistance than the reliable, but time-consuming, pack test method was investigated. Metal-to-metal junction potentials have always been fascinating from the standpoint that potentials should exist, but how are they measured?

Starting out on the basis that the tin-iron alloy layer quality might produce correlation between its composition and pack test results, tests were devised to check out the potential correlation. In conjunction with operating personnel, a sampling procedure was worked out so that laboratory test results and pack test results could be compared. In the laboratory procedure, tin was stripped from the samples with sodium plumbite; the samples were carefully washed and dried; exposed steel edges were coated with beeswax, and single potential measurement of the tin-iron alloy layer variable in carefully prepared citric acid solution was noted at definite time intervals over a 6-hr period. A deci-normal Calomel cell was employed as a companion single-potential cell.

It took about six months to get feedback on the

pack test results, and surprisingly good correlation was established between single-potential laboratory measurement and the pack test results. On the strength of these results, in an effort to provide more uniform tin-iron alloy layers, a philosophy on conduction reflow systems, that infrared temperature detector units be employed to control reflow current, has been promoted.

Also, the use of a combination of silicon and tin electrodes in the pickling bath was promoted. The basic concept is contained in The Electrochemical Society Transcript No. 66251, published in 1934. The process involves the use of silicon steel or duriron to make a part of the anode, and a tin ion addition to the pickling bath; this process has the advantage of depositing tin immediately upon the removal of oxide from the strip surface. If there is a relatively small iron content in the pickling solution, this process can be conducted at relatively high current densities, which will give an extremely fine-grain tin deposit in intimate contact with the deoxidized steel. The silicon electrodes have the added advantage of generating a surface film, thus preventing the transformation of ferrous iron into ferric iron in the pickling bath.

A rather interesting hot rolled stainless steel deoxidizing problem was present a few years ago. A decision was made to utilize an electrochemical deoxidizing process, the basic electrolyte ingredient being molten sodium hydroxide operating at temperatures above 900 F. The conduction roll idea of introducing current into the strip could not be used, and certainly anodes and cathodes could not exist in the same tank, if current flow through the rather high-resistant stainless steel was to produce the desired surface gasification. The solution was to employ two electrically insulated tanks, one containing the anode, the other the cathode, with the steel strip being the only electrical tie between the two electrodes.

SUMMARY

It is advocated that there be a return to some basic concepts. In modern technology, there is often an inclination to pass over some of the rudimentary laws and facts that were learned in school. One should start with Ohm's law, which is basic to the electrolytic processes, and take another good look at the initial electrolytic processes that are employed in the steel industry with special emphasis on electrolytic cleaning, pickling and coating. Remember that it is absolutely essential that a uniformly oxidized surface be maintained when the strip comes out of the electrolytic cells prior to plating. To achieve this effect, the correct polarity must be observed on the electrodes or conduction rolls employed in the process. It is also advocated that for electrolytic pickling, prior to coating, current densities in the order of 100 to 150 amp-sec should be used. Filtering of the pickling solution is strongly recommended. Mechanical alterations, such as "toeing-in" the electrodes or insulating the cell walls, should also be studied for application where necessary to induce proper conduction paths. All of these measures should suggest that better communications be instigated throughout the steel mills and the industry, in an attempt to thoroughly understand the ideal circumstances surrounding electrolytic processes.

Discussion

PRESENTED BY

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DR. WILLIAM E. TRAGERT, Metallurgist, Metallurgy and Ceramics Research Dept., Research Laboratory, and JOHN BARINAGA, Application Engineer, Metal Rolling and Processing Engineering, Industrial Engineering Operation, General Electric Co., Schenectady, N. Y.

E. E. VONADA, Product and Application Specialist, Reliance Electric and Engineering Co., Cleveland, Ohio

E. J. Smith: First recognition of the importance of electrochemical processes came with the introduction of tin and zinc plating. From that time the list of applications grew until today, all major steel companies treat strip in one way or another by these processes. They are not only efficient, but extremely fast. Consider that, in a line operating at 2000 fpm, the time allotted for cleaning may be as little as one sec. Plating current densities used in the electrogalvanizing of steel wire are reported to be as high as 5000 amp per sq ft. It is not unusual to electrodeposit tin on strip at current densities as high as 600 amp per sq ft. Actually, the limitations on the application are not related to the conditions imposed by electrolysis but rather to hydraulics since it is absolutely essential to have the wire or strip being treated in intimate contact with an aqueous solution. This becomes a major problem at strip speeds of 2000 fpm.

It seems that the author places too much emphasis on the importance of anodic treatment as the final treatment in the cleaning processes. The only reason for final anodic treatment is to prevent the deposition of metal ions which might have an adverse effect on the strip. Certainly, the evolution of hydrogen or oxygen cannot be important in view of the subsequent processes which generally take place.

As for the electrolytic pickling processes, the possibility of hydrogen entrapment, if the strip is cathodic, may be worth considering. However, most plating processes which follow are capable of discharging a considerable amount of hydrogen at the strip surface. It seems more important to anodically electropickle because of the desirability for dissolving metal (etching) or removing metal oxides on the strip. If a light oxide film is formed during anodic pickling, it would instantly dissolve during the rinse which follows and would be replaced by various ferric hydroxides.

Neal Johnson: There is an inclination to feel that the author probably overemphasized the importance of having the strip come out of the solution as anode.

The importance of understanding the terminology and laws of electrochemistry cannot be overemphasized,

and the author should be complimented for his thoughtfulness in setting forth definitions of elementary terms.

In an electrochemical process (Figure 2) the flow of the current is controlled by Ohm's law. In looking at Figure 2 one might wonder what the flow of the current is. It may be helpful to bear in mind that the current leaves at the anode and enters at the cathode. Admittedly, the circuit is quite a complicated system compared to a simple dry cell or chlor-alkali cell where one need consider only one cathode and one anode.

The author explained that the processors have done an excellent job in designing cells and in producing and arranging electrodes in electrolytic cleaning or plating systems. Still it is noted that the current efficiency at the steel strip may be only 85 to 90 per cent of theoretical, which is quite low. Further study of the system as described, employing ever greater attention to the laws of electrochemistry might well give improvements in cell operating characteristics.

What does the loss of five to ten per cent in efficiency represent in terms of dollars?

Again the author's plea for a better understanding of the laws of electrochemistry as applied to the steel industry should be emphasized.

D. C. McCrady: One must agree with the author that more thought should be given to fundamentals and their effect on the electrolytic processes, in the design of equipment layouts.

In using alternate duriron and tin anodes for pickling, what spacing is necessary from the strip in order to equalize tin-throwing power effect? Also, what current densities, acid concentration and temperature should be used?

In electrolytic processes where steel tanks are rubber lined, does the rubber act as a complete insulator from the standpoint of parallel paths?

In electrolytic cleaning, where plain steel tanks are used, has any consideration been given to the spacing relationship of the tank walls and bottom to the strip from the standpoint of parallel paths?

Dr. William E. Tragert and John Barinaga: The author makes the point that the final polarity of the steel strip is critical to the proper preparation for plating, on the basis that terminal cathodic polarization results in the entrapment of hydrogen. On the other hand, terminal anodic polarization is represented as being effective in removing the deleterious, absorbed hydrogen.

It is highly questionable that a brief anodic treatment can do more than remove from the steel that hydrogen which is adsorbed right at the surface. This is to say that any hydrogen that had previously entered the metal would probably not be readily removed by the anodic treatment. However, the removal of surface hydrogen may have some noticeable effect on the soundness of subsequent electroplating, or the formation of a thin oxide scale may constitute a beneficial conditioning of the surface with respect to subsequent deposition. In either case the truly dissolved hydrogen, unaffected by reversed polarization, remains beneath the electroplating and comprises a possible source of subsequent blistering and flaking. Needless to say, any incidental thermal cycling, even to temperatures as low as 212 F, will greatly enhance the desorption and blistering processes. By the same token, a deliberate thermal treatment intermediate to cleaning and plating could be expected to remove much of the harmful, entrapped hydrogen.

E. E. Vonada: Controversy was anticipated and no one has been disappointed. It is surprising that the controversy is limited to one general area.

In many plants cold rolled steel is still degreased in electrolytic cleaning lines as a separate process. In many cases, the coils stand around for weeks after they are cleaned before further processing. If the steel strip leaves the cleaning line with a hydrogen (cathodic) gas atmosphere as the last exposure, the hydrogen will have a tendency to be adsorbed in the grain boundaries of the steel. Another adverse effect of the final hydrogen exposure will be a complex oxide formation on the strip surface with time. In contrast if the strip surface is deliberately oxidized (anodic) in its final electrolytic cell treatment, a light, uniform oxide coating can be expected. This has been found to be of importance in electrolytic treatment of stainless steel.

Dr. Tragert read something into the article when he stated, "terminal anodic polarization is represented as being effective in removing the deleterious, adsorbed hydrogen." Hydrogen adsorption in steel is a time process. His statement is true to this effect, with short exposure time in normal electrolytic processes, there will be practically no effect on the entrapped hydrogen. This is essentially what was discussed.

The strip should not be exposed to hydrogen if it is not absolutely necessary, since it is known that hydrogen is poisonous to steel. A uniform oxide coating on the strip surface is beneficial, and if the pickling solution is properly controlled, no adverse effect of plating iron will be experienced. The dollar losses involved with a cell inefficiency of five to ten per cent (wasted electrical energy) might cost in the order of $100 per year.

With relation to the ratio of duriron to tin anodes for pickling, the anodes should comprise somewhere between 10 and 15 per cent tin. Spacing between the steel strip and electrodes need not be extended beyond the normal mechanical adjustment range provided in the vertical tanks. Satisfactory operation will require adjustment of the sulphuric acid to tin ion ratios to permit utilization of rather high current densities; and to produce the necessary condition where tin is deposited from the solution with stannous ions being replaced in solution at the tin anode, as an anode reaction. Current densities should be in order of 250 to 300 amp per sq ft, and bath temperatures should be normal room temperatures.

Rubber-lined tanks act as a complete insulator from the standpoint of parallel paths in the electrolytic cell.

Stray current losses in steel tanks is an area that requires study in every electrolytic process. In many installations, current is flowing through steel tank sides and bottom and is of no benefit to anyone. It was suggested that cell constants be checked out to determine how much stray loss currents were flowing through the tank elements. The article described the method used to check the cell No. 1 type. Cells similar to the Nos. 2 and 3 types can be checked by providing an electrical tie between the conduction roll and the tank itself. ▲

Electric Furnaces or Cupola-Basic Oxygen Converters?

by J. M. BERTRAM, Principal Engineer,
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. . . . the following supplements the article, "Electric Furnace or Cupola, Basic Oxygen Converter for the Nonintegrated Steel Plant," by D. A. Sutch and H. C. Manley which appeared in the July, 1961, Iron and Steel Engineer . . . .

"ELECTRIC Furnace or Cupola, Basic Oxygen Converter for the Nonintegrated Steel Plant," by D. A. Sutch and H. C. Manley in the July, 1961, *Iron and Steel Engineer* is a fine article on a subject that has not as yet received sufficient attention. However there are some aspects of the article wherein our company has information that is not generally available. The following comments pertain to those data relating to the plant producing 250,000 tons per year which is assumed to be operating on a continuous basis of 21 turns per week.

The authors' closing statement has our full endorsement as the evaluation of the L-D process (basic oxygen process) for use in the various parts of the U. S. has taught the necessity for using data related to a specific plant. One cannot justify the installation of facilities requiring large capital expenditures until a careful analysis of local conditions has been made. A relatively small error in the assumed savings per ingot ton to be obtained from the new facilities may alter the pay-out period and therefore the desirability of the project. It goes without saying that such an error could make the project either more or less desirable.

The authors selection of plant locations certainly show the effect of local conditions on the operating costs of any plant. One might question the value of making a comparison of 250,000-ton plants in Portland, Ore., when the only steel mill in Oregon has a capacity of 150,000 tons. This low production would cause a scarcity of some raw materials and therefore would adversely affect the production costs of the hot metal plant.

The use of a standard plant design to establish plant costs for a variety of clients in different locations, has, in our experience, proved to be unsuitable. Here again, due to local conditions it is necessary to make a separate design for each client in order to accurately predict plant costs. Scaling a standard plant layout up or down to suit different production requirements usually results in unrealistic plant costs. It has been found economical to tailor the building area and cross section to the specific requirements for each particular plant.

The selection of a properly sized L-D furnace is the most critical factor in laying out a plant as the furnace size sets the size for all other facilities and thereby governs the plant cost. A full appreciation of the speed of the L-D process is necessary in order to realize the inherent advantages of the process. As an example, there are 35-ingot ton furnaces now operating on tap-to-tap cycle of 35-min when making low carbon steels. The Cuscoleca-Rosner article[1]* referred to by the authors states that high carbon heats require an additional four minutes. On this basis, the 30-ton furnaces, selected by the authors, could produce 400,000 tons per year when making nothing but high carbon steels requiring the 39-min cycle. The extended cycle chosen by the authors has resulted in oversizing the furnace which results in higher plant costs in facilities such as cranes, transfer cars, ladles, etc., since everything is sized to produce 400,000 tons rather than the 250,000 tons required. Using an acceptable method to adjust for the difference in size, one could then reduce the plant costs to about 75 per cent of those given by the authors. Further, the L-D portion of the plant shown in their Figure 1 has, in our opinion, considerably more floor area than is required for a plant to produce 250,000 tons annually.

The inclusion of the cost of the oxygen generating plant is the factor which in the two larger L-D plants raises their cost above that of the electric furnace plants. This approach by the authors does not present a realistic picture of current practices concerning the use of large quantities of oxygen. Inasmuch as the majority of the on-site oxygen generating plants that have been built in recent years are not owned by the steel companies, it is no more logical to charge the L-D—cupola plant with these capital charges than it would be to charge the electric furnace plants with the capital charges for an appropriately sized power plant. Due to the competitive nature of the gas producing industry, oxygen is now a utility that can be purchased in much the same manner as power or fuel.

Deducting the cost of the oxygen generating plant and reducing the engineering cost in proportion, the 250,000-ton per year plant cost now becomes $7,600,000 and the cost per annual ton is $30.40. This adjustment reduces the financial charges to about $3.65 per annual ton. Were a more rigorous analysis made of the fur-

* Numbers in parentheses refer to Bibliography at end of article.

nace size required and appropriate adjustments in other equipment size, it is believed the plant cost per annual ton might be as low as $25 and the financial charges would then be about $3.00.

Due to the considerable work we have done in the development of plant and operating costs we are the first to recognize the controversial nature of any estimated costs. Therefore, it is desired to be conservative in the costs that are suggested to be substituted for those given by the authors.

It is interesting to note the differences between the cupola charge selected by the authors and those used in actual practice by Sheffield and Laclede[2] for the production of hot metal to be used in their open hearths. The variation in hot metal costs given by E. S. Harman[2] show that by proper cupola charge selection one could reduce the cupola metal cost used by the authors from $57.40 per ton of iron to $33.50 per ton of iron. The scrap charge selected for the basic oxygen furnace is composed of a higher percentage of heavy, high priced scrap than is normally used in existing operating plants. Using the scrap prices quoted and the normal mixture of heavy and light scrap would reduce the scrap charge cost by about $1.00 per ton. In this event the net metal cost could be as low as $38.00 or as high as $43.00.

As a detailed cost above was not included in the article it is not possible to analyze the $25.74 figure given by the authors. If one grants that the conversion cost of $6.50 per net ton given by E. S. Harman[2] is realistic for the cupola, then the L-D plant is being charged with a cost above of $19.54. In the many studies we have made concerning the use of L-D furnaces, only under the most adverse conditions has the cost above ever approached $15.00 per ingot ton even when considering plants having a capacity of 100,000 tons. The normal range of cost above for L-D plants now in operation is between $6.00 and $12.00 per ingot ton. Therefore, it is believed that the L-D cost above given is overstated by a minimum of $5.00 per ingot ton. This view can also be drawn from a recent paper by Van Voris.[3]

Taking the authors' tabulation for the 250,000-ton per year plant in the Pittsburgh area and making conservative adjustments to the cupola—L-D (Basic Oxygen Process) costs as indicated above, one finds that under these conditions the cupola—L-D combination is appreciably less expensive in all respects except for the net metal costs. On this basis, the cupola—L-D produces ingots about four per cent lower in cost compared to the electric furnace and the savings might be as high as 20 percent.

	Estimated Ingot Costs			
	Electric furnace	*Cupola-basic oxygen*	*Adjustment range*	*Adjusted cupola-basic oxygen (L-D)*
Net metal	$36.15	$42.91	$38.00–43.00	$40.00
Cost above	26.19	25.18	12.50–25.75	20.00
Fixed charges	3.77	4.27	3.00– 3.65	3.50
Total ingot cost	$66.11	$72.36	$53.50–72.40	$63.50

The advantage of a more continuous flow of metal from an L-D furnace should be related to the possible savings in the over-all plant operation. It is believed that the smaller and more frequent heats may result in savings in plant equipment and building area. There are also disadvantages to small heats, which are recognized, and therefore, this is another reason a thorough investigation rather than the use of generalized information is recommended.

In conclusion the two major points of disagreement with the authors are:

1. The selection of basic oxygen (L-D) furnaces which are almost fifty per cent larger than required for all three plants compared.
2. The inclusion of the capital cost of an oxygen generating plant.

The seven years we have spent in the development of the basic oxygen steel (L-D) process in the United States has provided considerable experience in the development of plant and operating costs for this process; therefore, we know that the L-D—cupola combination is more competitive with other steelmaking processes than this article indicates. We are also in agreement with the authors that the final decision to use this steelmaking combination must be based upon a detailed study made for each specific situation.

BIBLIOGRAPHY

1. 'L-D Produces Alloy Steel in Austria," by Cuscoleca and Rosner, Journal of Metals, October 19, 1958.
2. "Cupola Metal Increases Open Hearth Production," by W. H. Steinheider, *Iron and Steel Engineer*, July, 1961.
3. "Basic Oxygen Steelmaking," by Van Voris and Crane, Transactions American Foundrymen's Society, 1960.

Discussion

PRESENTED BY

D. A. SUTCH, President,
Ramseyer & Miller, Inc.,
New York, N. Y.

J. M. BERTRAM, Principal Engineer,
Steel Plants Development Dept.
Kaiser Engineers, Div. of Henry J. Kaiser Co.
Oakland, Calif.

D. A. Sutch: Mr. Bertram's discussion brings forth many of the problems that we had to first recognize, then face and finally evaluate in the development of the article attempting to compare the two steelmaking processes.

Many of the points raised cannot be established on a fully definitive basis as the experience as well as the opinions of different people very rarely lead to one common point of agreement on any subject. Thus we do not make any claim that our ultimate capacities, operating or capital costs, were given with watchmaker's precision for our past experiences have shown that the acumen of of specific operators, local working conditions, etc., have their own effects on both "capacities" and operating costs of the same pieces of equipment.

We made the selection of the Portland, Oregon, area as an area having extremes for "high" coke cost and "low" electricity cost while at the same time lacking two of the desirable materials of a fully integrated plant—copious supplies of at least intermediate grade iron ore and coking coal. With Seattle less than 200 miles away

and having two plants with a total capacity of 300,000 tons, this area can be considered a 450,000-ton capacity area.

We do not follow the logic of the discussion when it states . . ."This low production would cause a scarcity of some raw materials and therefore would adversely affect the production costs of the hot metal plant." We believe the opposite to be true—that a low production would increase the supply and decrease the cost of the prime raw material, which is ferrous scrap.

The point covering "standardization" of plants is well taken and was recognized in the article which pointed out that the "capital (and later costs above) are based upon specific equipment" and plants. In this case we used the same plant, at different locations, to produce ingots for the same product and after adjusting for local variables, developed our cost predictions. We also believe that under the established conditions the plant(s) would prove suitable for the operation for which they were hypothetically planned, regardless of the section of the country in which they were located.

A question is raised in regard to the capacity of the L-D shop. We have examined the operating records and observed the operation of one plant that is tapping 33 metric ton heats on a 35-min cycle. We are also familiar with a second plant averaging 42 min on the 33-ton heats. The production of both of these plants is almost entirely low carbon steels while the crane facilities and labor requirements for the first plant are far beyond that which we have considered in our capital or production cost estimates. The original article set forth our deliberations on the heat times for higher carbon steels by the basic oxygen process. Seeing three additional operations in the last year and discussions with three groups of equipment manufacturers have not caused any decided change in our views, especially when one considers a day in day out operation with unavoidable delays, breakdowns, etc. The capacity used in our study quite well agrees with an annual production guarantee recently given by a large manufacturer. The guarantee for a shop having 25 metric ton vessels (single vessel operation) was 234,000 tons for a full operating year—but as extrapolated on the basis of a relatively short "test" period. The original article recognized the basic oxygen shop as having a much greater reserve capacity than the electric furnace shop, but at the same time points out the flexibility advantage of the electric furnace plant as a possible offset under poor business conditions.

Under some conditions—such as, becoming an additional consumer of a presently existing O_2 plant or one of the customers of a new large O_2 plant—the possible advantages of purchasing O_2 must be recognized. However, if the O_2 plant is built for the sole use of a steel plant and is operated and depreciated under similar conditions, the steel plant alone must pay for the cost of producing O_2 and for depreciating the plant whether the steel plant operates the plant or buys its O_2 as a utility.

The matter of metal burden has almost as many solutions as there are operators. The differences of opinion are true for both the electric furnaces and the oxygen steelmaking plant. We know one recognized operator who classifies No. 2 bundles as an unsuitable electric furnace charge material, while another has expressed that increasing the use of No. 2 bundles to 30 per cent (from the 20 per cent used in our study) of the charge would be a more reasonable procedure. It was in recognition of this divergence of thought that we discussed our burden and hoped that readers, if interested, would make adjustments in accordance with their own convictions.

Operating data that we have seen and used indicates that the refractory expense connected with the cupola, the transfer ladles, the hot metal mixer, the L-D vessel (both linings) and the steel pouring ladles plus ingot molds and oxygen cost well exceeds the minimum of $6.00 per ton that has been stated.

The tabulation of "Estimated Ingot Costs" and the "Adjusted" figure are based on many changes from the premises of the original article. We attempted to give a comparative unbiased study and believe that under the conditions described, we were equally fair to both processes.

Actual available operating data on electric furnace operations, even though with great variance from plant to plant, is far more numerous than that of small basic oxygen operations. Additionally, the electric furnace has had a long period of time to refine its techniques, costs, etc., while the basic oxygen process has had a relatively short commercial application, so that a review of the matter five years from now should show some improvement in operational costs for the cupola-basic oxygen shop.

If our final recommendation—to employ a comprehensive comparative study for the determination of the steelmaking process to be used at a new plant is followed—the most economical process should result. By removing the suppositions that necessarily were the basis of our study and further expanded by Mr. Bertram, and replacing them with actual material costs, product mixes, etc., cost of utility oxygen, etc., one can evaluate the various steelmaking processes under the specific conditions to which they will be applied and operate and thus select the best for each specific new melt shop.

J. M. Bertram: The comment on the placement of a plant in Portland, Ore., was related to the fact that the production capacity of the Northwest area has remained almost constant for some ten years in spite of the new Bethlehem Steel Plant built last year in Seattle. Therefore, it was concluded that an additional 250,000-ton plant would not be feasible in the Portland area. From recent publications, it was noted that the scrap price in the Northwest is considerably higher than that of the San Francisco Bay area or other areas of higher steel production. Therefore, it is felt that Mr. Sutch's statement is incorrect. The standardized plant design used by Mr. Sutch would be suitable for all locations, but it is felt that it would be more expensive than necessary. With regard to annual capacities which are a function of both vessel size and heat cycle, the point to be made is that it is not reasonable to use 1-hr heat times for small furnaces when the U. S. average for large furnaces is about one hr.

It was pointed out that few, if any, steel companies are purchasing oxygen plants; therefore, the oxygen cost, including depreciation, shows up in cost above and not in capital costs. If Mr. Sutch used published oxygen costs he is adding in depreciation costs twice, as the selling of oxygen must include capital charges.

Moreover, it was felt that without a detailed cost-above statement, it is not possible to make a direct comparison; therefore, alternate values which are based on actual operating data were offered. ▲

CURRENT AISE DISTRICT SECTION MEETING NOTICES

BIRMINGHAM SECTION

Monday, January 29, 1962—Social Hour 6:30 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Engineering and Automation in the Soviet Iron and Steel Industry," by W. E. Miller, Manager, Metal Rolling & Application Engineering, General Electric Co., Schenectady, N. Y.

Redmont Hotel, Birmingham Ala.

BUFFALO SECTION

Tuesday, January 9, 1962—Dinner 6:30 P.M., Meeting 8:00 P.M.

"Selective Oxygen Flame Enrichment in the Open Hearth," by R. Lee, Canadian Liquid Air Co. Limited.

Hotel Sheraton, Buffalo, N. Y.

CANTON SECTION

Monday, January 15, 1962—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"The Customers' Probable Quality Requirements During the Next Five Years," by Glen Boston, Manager of Quality Control, Ford Motor Co., Canton, Ohio; Don Armour, Chief Metallurgist, Union Drawn Steel Div., Republic Steel Corp., Massillon, Ohio; and Ralph Wilson, Director of Metallurgy, The Timken Roller Bearing Co., Canton, Ohio

Mergus Restaurant, Canton, Ohio

CHICAGO SECTION

Tuesday, January 2, 1962—Dinner 6:15 P.M., Meeting 7:45 P.M.

"Blast Furnace Practice," by William O. Bishop, Superintendent, Blast Furnaces, Inland Steel Co., East Chicago, Ind.

Phil Smidt's Restaurant, Whiting, Ind.

CLEVELAND SECTION

Tuesday, January 23, 1962—Social Hour 6:00 P.M., Dinner 6:30 P.M., Meeting 7:45 P.M.

"Upgrading and Development of Engineering and Maintenance Personnel," by Dr. J. S. Kopas, Training Counselor, Republic Steel Corp., Cleveland, Ohio

"Control of Maintenance Costs," by R. W. Herrmann, Superintendent Engineering and Maintenance, Cuyahoga Works, American Steel and Wire Div., United States Steel Corp., Cleveland, Ohio

"Lubrication Engineering for the 1960's," by A. J. B. Fairburn, Supervisor of Technical Services, Lorain Works, National Tube Div., United States Steel Corp., Lorain, Ohio

"Effect of Automation on Type of Maintenance of Steel Mill Controls," by Marshall W. Davies, Superintendent of Maintenance, Cleveland Works, Jones & Laughlin Steel Corp., Cleveland, Ohio

Cleveland Engineering & Scientific Center, 3100 Chester Avenue, Cleveland, Ohio

COLORADO SECTION

Tuesday, January 16, 1962—Dinner 7:00 P.M., Meeting 8:00 P.M.

"Management as a New Profession," by G. A. Jedenoff, General Superintendent, Geneva Works, Columbia-Geneva Steel Div., United States Steel Corp., Provo, Utah

Minnequa University Club, Pueblo, Colo.

DETROIT SECTION

Tuesday, January 9, 1962—Dinner 6:30 P.M., Meeting 8:00 P.M.

Ford Steel Division Night

"Annealing and Steel Surface Problems," a round table discussion led by A. Krause, Production Manager, Steel Div., Rouge Plant, Ford Motor Co., Dearborn, Mich. (Round table discussion participants will be announced later.)

Dinner, Cafeteria; Meeting, Auditorium, Central Office Building, Ford Motor Co., Dearborn, Mich.

LOS ANGELES SECTION

Monday, January 8, 1962—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Aspects of the Unmanned Lunar and Planetary Space Program," by Dr. Frank Goddard, Assistant Director, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, Calif.

Orlando's Restaurant, Pomona Calif.

PHILADELPHIA SECTION

Saturday, January 6, 1962—Dinner 6:00 P.M., Meeting 7:00 P.M.

"The Use of Recuperative Stacks on Sparrows Point's 56-In. Hot Strip Mill Slab Reheating Furnaces," by Herman C. Henschen, Special Engineer, Fuel Dept., Bethlehem Steel Co., Sparrows Point, Md.

"A Modern 11-In. Reinforcing Bar Mill," by R. E. Jones, Superintendent 11-In. Bar Mill, Steelton Plant, Bethlehem Steel Co., Steelton, Pa.

Engineers' Club, 1317 Spruce St., Philadelphia, Pa.

PITTSBURGH SECTION

Monday, January 8, 1962—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Maintenance Symposium," Chairman, Elmer E. Barthel, Assistant Superintendent, Maintenance, Pittsburgh Steel Co., Monessen, Pa.

"Mechanical," by J. R. Dickey, General Foreman, Maintenance Div., Jones & Laughlin Steel Corp., Aliquippa, Pa.

"Electrical," by G. W. Davis, General Foreman, Electrical Maintenance, Crucible Steel Co. of America, Midland, Pa.

"Construction," by G. G. Lloyd, Superintendent, Construction, Pittsburgh Steel Co., Monessen, Pa.

"Electronics," by G. A. Bricker, Jr., Electronic Repair Supervisor, Allegheny Ludlum Steel Corp., Brackenridge, Pa.

University Club, University Place, Pittsburgh, Pa.

ST. LOUIS SECTION

Wednesday, January 31, 1962—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"Present and Future Advanced Electrical Drive Systems for Primary Metals Industry Processes," by E. H. Browning, Manager, Metal Working Section, Industrial Engineering Dept., Westinghouse Electric Corp., East Pittsburgh, Pa.

Elks Club, Granite City, Ill.

SAN FRANCISCO SECTION

Tuesday, January 16, 1962—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

Columbia-Geneva Steel Division Night

"The Oahe Dam and Reservoir Project Tunnels," by Milton Carr, Chief Engineer, Consolidated Western Steel Div., United States Steel Corp., Maywood, Calif.

Spenger's Fish Grotto, 1919 Fourth St. (near University Ave.), Berkeley, Calif.

UTAH SECTION

Monday, January 8, 1962—Social Hour 6:30 P.M., Dinner 7:30 P.M., Meeting 8:30 P.M.

"Marketing Steel," by R. C. Meyers, Director Market Development, United States Steel Corp., Pittsburgh, Pa.

Grandview Cafe, Provo, Utah

YOUNGSTOWN SECTION

Monday, January 22, 1962—Social Hour 6:00 P.M., Dinner 7:00 P.M., Meeting 8:00 P.M.

"A Timely Discussion of Top Level Thinking in the Steel Industry," by H. C. Lumb, Vice President, Director of Law and Corporate Relations, Republic Steel Corp., Cleveland, Ohio

Mahoning Country Club, Girard, Ohio

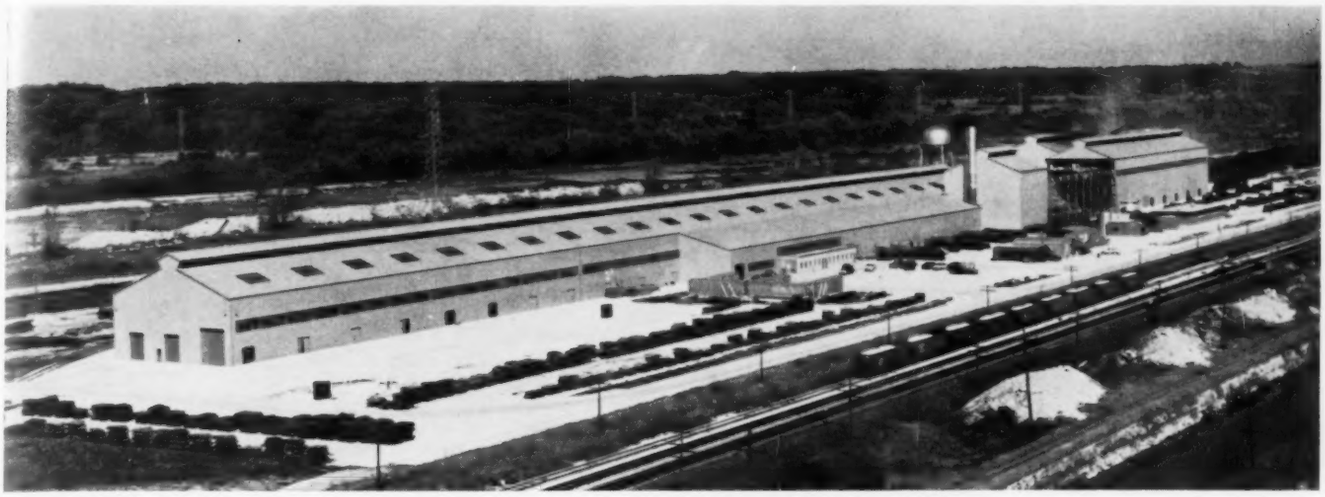


Figure 1 — The plant is located adjacent to rail, water and truck transportation facilities.

Ceco's Ochiltree Works Modern Electric Furnace, Bar and Merchant Mill

by W. B. JACOBSEN
Works Manager
Ochiltree Works
Ceco Steel Products Corp.
Lemont, Ill.
and LAWRENCE S. BARKER, JR.*
Project Engineer
The Rust Engineering Co.
Birmingham, Ala.

. . . . billet-sized ingots, poured in an adjoining modern electric melt shop, are rolled on a flexible merchant mill. A wide product range is made possible, with minimum roll changes, thus reducing over-all costs . . . .

FOR the past few years Ceco Steel Products Corp. had seen their need grow for a firm source of steel. As a result, in February, 1958, Ceco retained an engineering firm to design and construct a complete steelmaking facility.

Prior to contract signing, options had been obtained on an 88-acre tract of land located along the south bank of the Chicago Sanitary and Ship Canal, approximately 1½ miles southwest of the village of Lemont, Ill. This proved to be an ideal location, since the plant is bordered on the north side by the canal, which provides barge transportation for bulk material to all points served by the Mississippi river system; on the south side by the main line tracks of the Santa Fe Railroad; and is close to a main highway network, which provides for good truck and rail transportation. The site is also ideal since the geological formation of the area greatly aided construction.

The Lemont mill (Figure 1) was separately incorporated as the Lemont Manufacturing Corp., and this remained the name of the facility until it was changed to the Ochiltree works, in honor of Ned A. Ochiltree, Sr., chairman of Ceco's board of directors.

The plant, as originally conceived, was to be a 2-furnace, electric furnace melt shop with a capacity of 120,000 annual net tons of billet-size ingots; and a 12-stand rolling mill, semi-automatically operated, to produce at a minimum capacity of 110,000 annual net tons of finished products. These products were to range in size from No. 3 through No. 18 reinforcing bar, were to

* At time of presentation, now with Graver Tank and Manufacturing Co., Div.—Union Tank Car Co., Joliet, Ill.

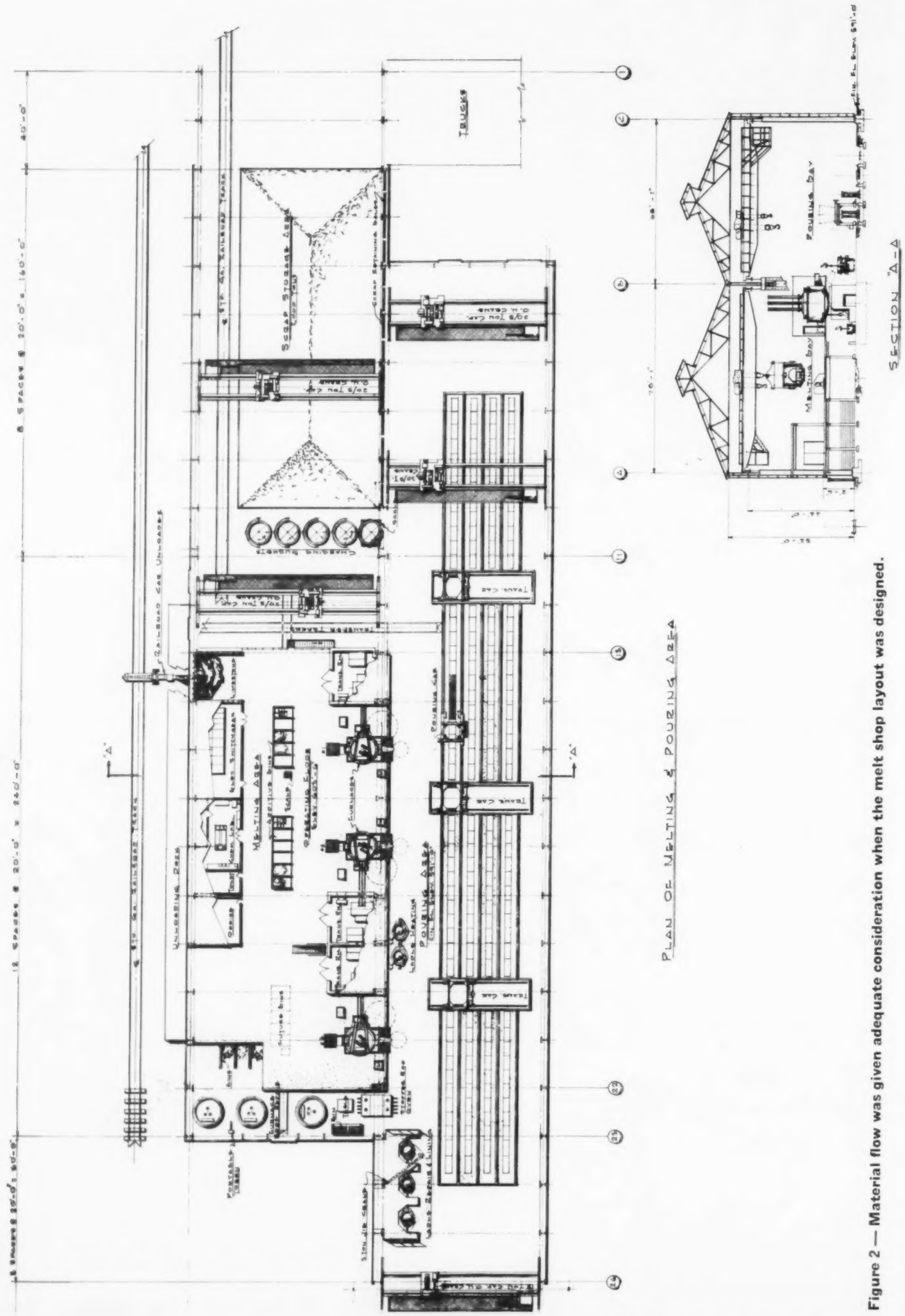


Figure 2 — Material flow was given adequate consideration when the melt shop layout was designed.

include angles up to 4 x 4 x 3/8 in. and were also to include certain quantities of other merchant products. Heaviest production emphasis was to be reinforcing bars. A total of 62 product sizes were to be produced.

In order that the plant be placed in production at the earliest possible date, major equipment orders were let as soon as feasible after the contract was signed.

The electric furnace criteria information specified that quotations were to be on two electric-arc furnaces, which would produce 18 to 20 tons per heat. These furnaces were to be furnished complete with transformers, hydraulic systems and all necessary auxiliary equipment. The first two were 12-ft shell diameter electric-arc furnaces.

Inquiries were sent to major rolling mill equipment manufacturers for quotations on a semi-automatic mill designed to produce the required tonnage of the production range previously specified. The mill was to be operated with a minimum of labor and a maximum of flexibility, with all products to be rolled from billet-size ingots. All proposed layouts were carefully evaluated, and prior to placing the mill purchase order, the selected supplier was required to incorporate in their mill layout certain modifications and changes. A purchase order was placed in May, 1958, with delivery of mechanical equipment to begin in December. During the time of furnace and mill purchasing, other major items such as structural steel, overhead cranes, etc., were placed on inquiry and purchased. Following purchase of the rolling mill mechanical equipment, inquiries were sent to major electrical equipment suppliers for mill drives, controls, etc., and in July orders were placed for the rolling mill electrical equipment, plus all plant auxiliary electric equipment. The latter equipment included outdoor switch gear units, unit substations, rectifiers for plant d-c power, etc.

Engineering for the project began immediately after the contract was signed in February. The schedules called first for completion and operation of the melt shop, and second for completion and operation of the rolling mill, together, of course, with the required auxiliary equipment for both divisions of the plant.

In the early summer of 1958, plant railway sidings and switch tracks were installed, and in July excavation started for the melt shop foundations. Erection of building structural steel began in September. Steel erection, with all auxiliary work, was completed and the building was enclosed in January, 1959. The electric-arc furnaces, together with auxiliary and main electric power feeders and equipment, pouring pits, crane erection, water supply, etc., were completed in late March, and the first ingot was poured on April 6, 1959, one month ahead of schedule.

The purpose of early melt shop completion was to provide a stock pile of billet-size ingots, so that when the rolling mill operations were begun an adequate source of ingots would be available.

The basic building structure was of the standard mill type, a steel frame building with corrugated, galvanized steel roof and siding. Ventilation for this 60,000-sq ft, 2-bay building was provided by continuous open monitors along the ridge line of each bay. Building foundations were standard footing and pier construction, and the solid limestone rock formation underlying the entire plant site provided excellent foundation bearing. For the purpose of design, foundation bearing was computed on the basis of 12,000 lb per sq ft.

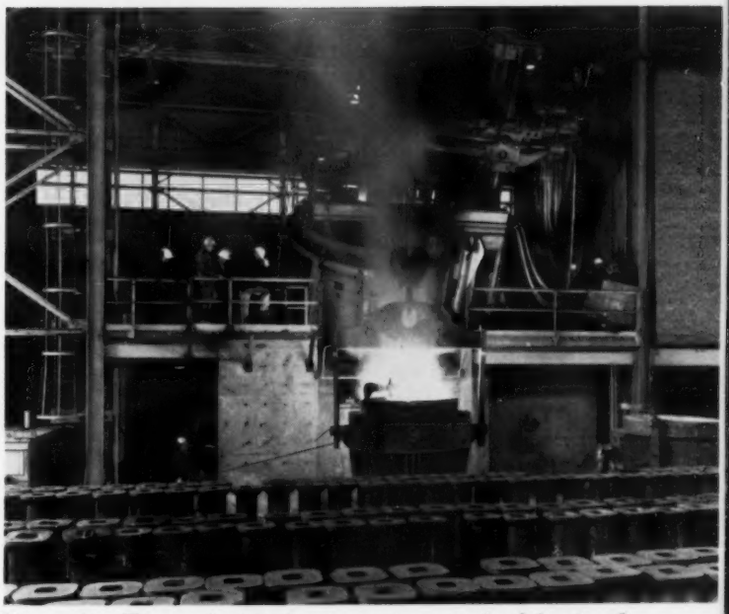


Figure 3 — Three electric furnaces tap nominal heats of 20 tons each.

Figure 2 shows the melt shop layout and indicates the location and relationship of both equipment and areas described.

The north bay of the melt shop includes areas for covered scrap storage, melting and service. The south bay includes the pouring pits and ladle maintenance sections.

Adjoining and immediately to the west of the pouring bay is a 180-ft open craneway for billet storage. This craneway connects the melt shop with a charge area of the rolling mill reheating furnace. The covered scrap storage space in the north bay provides dry scrap for immediate use in the furnaces, particularly during the extremely cold icy weather, when moisture in the form of ice or snow would cling to the scrap. This 230-ft long, 78-ft wide area also contains scrap bucket makeup and charge scale stations. Both the melting and scrap areas are serviced by two 20-ton capacity cranes, with 5-ton auxiliary hoist.

The melting area proper contains three 12-ft shell diameter, electric-arc furnaces with their required auxiliary equipment including three 7500 to 10,000-kva forced-water-cooled transformers, see Figure 3. The furnaces, together with the transformers, are located on a 14,400-sq ft concrete mezzanine deck, which is elevated 12 ft above the main operating floor. Also, located on the mezzanine deck are three 520-sq ft brick furnace transformer rooms, and a 2000-sq ft enclosure, which houses the melt shop superintendent's office, the comfort stations, the chemical laboratory and the auxiliary electrical switchgear room. A limestone storage bin and portable, compartmented, additive storage bins for each furnace are conveniently located on the mezzanine. Each storage bin is provided with direct access from a concrete unloading dock and the adjacent railroad siding. Supplies may be readily moved from the bins by means of narrow gage tracks located centrally under the mezzanine, or by a fork lift which operates in all areas of this dept. The area immediately under the mezzanine

serves as storage space for the various components required in the melting process. The remainder of the melting bay is open for furnace roof makeup and repair area.

The 68-ft wide, 620-ft long pouring bay contains four, 80-ft pouring line sections, each section consisting of four double lines of ingot molds. Space was thus provided for 1800 billet-size ingot molds.

Two 30-ton cranes were installed in the pouring area to transport ladles filled with molten steel to two gantry-type, electrically-powered pouring cars, which in turn move the ladle to the proper position over each mold. To provide rapid transfer of pouring cars between mold lines, three electrically-driven transfer cars were installed between the four mold line sections. Both transfer cars and pouring cars were supplied with jog-type electrical controls for accurate positioning of ladle spouts, and ladle supports were mounted on a turntable which allows ladle spouts to be shifted to either mold line.

The two 30-ton ladle cranes are augmented by a 15-ton crane, which is utilized for ingot stripping, storing and charging of the rolling mill furnace. A 12-ton capacity fork lift truck is utilized to store and move ingots to and from the yard storage areas.

The 2-bay building with furnaces located on a mezzanine above the main operating floor level provides a good material flow with a resultant savings in operating labor. The mezzanine installation also provides easy access to the furnace hydraulic equipment for better and less expensive installation and maintenance. The elevated furnace mounting decision was influenced by the solid limestone substructure at the plant site. A pit-type furnace installation would have been quite expensive, due to the required deep rock excavation.

Staffing and developing an operating crew in a new steel mill is not an easy task. Basically, supervision and operating crews were hired without robbing workmen from other steel plants. The supervisory force was acquired, generally speaking, from men who wanted to move or men who were free at the time. These men were hired early in the game, and aided in drawing up a working contract and a working rules program. They also aided the personnel manager in selecting workmen for their own departments. Except for supervision, the plant was manned solely with men without operating experience. They came from all walks of life, and from all over the country.

The first furnace was released to the operating department on April 2, 1959. The crews then on the site burned in the bottom on A furnace and tapped the first heat on April 6, 1959. This furnace was operated for 30 days until all the "bugs," both electrical and mechanical, were eliminated. The same crew then moved over and installed the bottom of B furnace and placed it in operation. Supervision moved as rapidly as possible to get both furnaces into operation, and were successful by October 26, 1959, in having operating crews to man both furnaces 20 turns per week. The 21st turn of each week is utilized for departmental maintenance.

Soon after the initial engineering contract was signed, it was decided that provisions would be made for the installation of a third electric-arc furnace, equal in size to the first two furnaces; this furnace to be added immediately on completion of the original plant.

The third furnace went into operation on March 11, 1960. The operating men for this furnace were obtained by splitting the men on A and B furnaces and moving them to higher rated jobs, the new men then taking the jobs in the pit area.

The chief trouble with starting an electric furnace department such as this was not so much in making steel as it was in developing continuity in operation and co-ordinating the auxiliary equipment and workmen, to handle the material after it was produced. Despite the troubles, and the mistakes made by inexperienced people, production followed closely the anticipated curve. Table I gives the monthly production through late 1960.

TABLE I
Furnace Production

Month	Tonnage
1959	
April	519
May	1,633
June	2,957
July	4,557
August	5,146
September	5,785
October	6,569
November	7,537
December	8,189
1960	
January	8,727
February	8,890
March	9,409
April	11,423
May	11,177
June	12,521
July	12,415
August	13,000
September	13,500
October	15,250
November	15,250

Crew	Date Crew Added
B furnace crew two	May 11, 1959
B furnace crew three	May 25, 1959
A furnace crew one	June 15, 1959
A furnace crew two	July 22, 1959
A furnace crew three	Oct. 19, 1959
A furnace crew four	Oct. 26, 1959
B furnace crew four	Oct. 26, 1959

Third furnace went into production March 11, 1960

ROLLING MILL

Rolling mill building construction began in late July, 1958, with blasting for foundation excavations. Building steel erection was started in November, but due to late steel deliveries and extremely cold, snowy weather during December and January, steel erection was not completed until January, 1959.

The rolling mill building proper was the standard mill-type, structural steel frame building with galvanized, corrugated steel siding and roofing. Panels of translucent, corrugated fiber glass sheets were installed in the roof, and these skylights added greatly to daytime light level. Ventilation was provided by a continuous open monitor, extending the entire building length as was the case in the melt shop. The 78-ft wide, 940-ft long structure housed rolling mill mechanical equipment and some mill drives. Three, 15-ton capacity, overhead cranes serve the mill and the mill shipping area.

Lighting in both the rolling mill and melt shop was

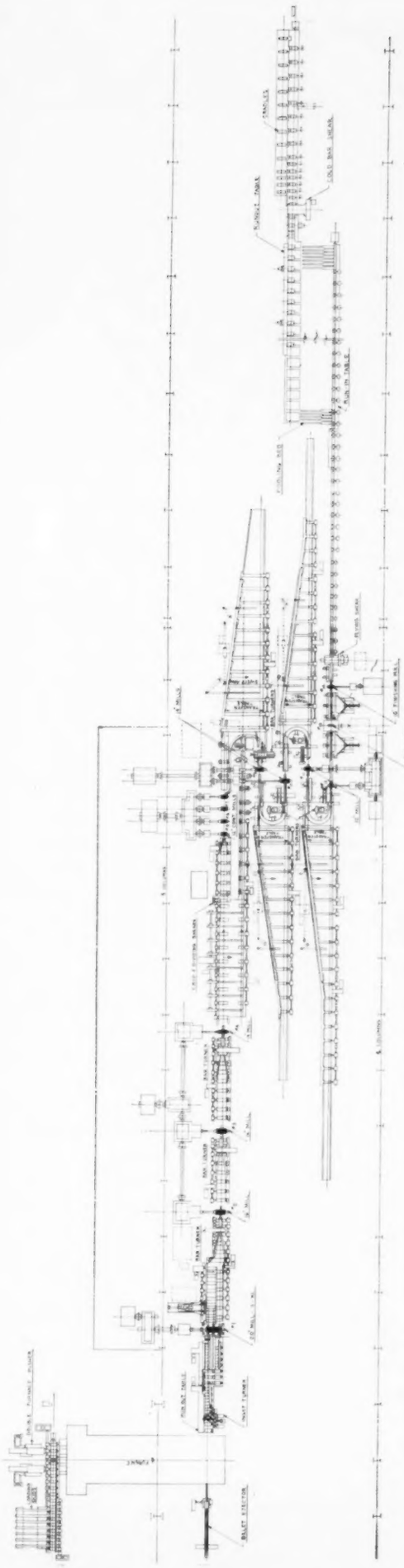


Figure 4 — The in-line roughing train is used in rolling the smaller sizes of rod.

provided by high-bay, 277-volt mercury vapor lamps, spaced to provide a minimum of 15 ft-candles of night time lighting.

A steel frame leanto was erected adjacent to the south side of the mill building to house the main mill motors, switchgear room, mill roll shop and plant maintenance shops. This 40-ft wide, 420-ft long structure was, like the other main plant buildings, covered with corrugated galvanized steel siding and roofing.

The 240-ft long motor room portion of the leanto was by necessity insulated with asbestos board on the inner walls and ceiling, and the roof area was packed with rock wool insulation bats. Clean (cooled in summer) air is provided to the motor room by a 61,300-cfm ventilation system, which draws air through a water-bath filter. A back pressure of ¼-in. water column is maintained in the motor room to prevent infiltration of dust and other debris which might foul electrical contacts. Oil-fired space heaters are provided in the motor room and in the other divisions of the leanto structure, as required by working stations.

Rolling mill foundation work started in February, 1959, and equipment settings began in March. Rolling mill foundation design was not completed until May; but because of close co-ordination between designers and construction forces, no mill equipment erection delay was experienced. Scheduled rolling mill startup was October, 1959; however, the first steel was rolled through the mill on August 20, and actual mill operations began five days later.

The reheating furnace was designed specifically to reheat billets of the size range required for economical operation in the mill. This 35-ton hourly rated capacity furnace is nonrecuperative, zone controlled, 2-zone, over and under-fired, end charged and side discharged. Physical dimensions of the furnace are 17 ft-2 in. wide by 56 ft-7 in. long outside of brickwork, which provides an effective heating length of 50 ft. Four water-cooled skid pipes in the furnace provide for continuous heating of a double row of ingots.

Normal furnace fuel is natural gas; however, because of the uncertain gas supply in the Lemont area, an auxiliary fuel oil system was provided. Furnace burners are a combination type, and either natural gas or fuel oil may be burned with equal ease.

Auxiliary fuel storage was provided by two 38,000-gal capacity storage tanks erected on concrete cradles within an earth dike. Oil storage area was located on the canal bank and pumps, heaters, strainers, etc., were installed adjacent to the tank area to provide ready access to tank car, truck and barge delivery.

The final design of rolling mill equipment was the result of the combined engineering of Ceco, the engineering firm and the mill supplier, and was of course based on Ceco's production requirements for product mix and quantities of finished products. Whenever possible, the mill equipment was "standard" design; however, much of the mill was by necessity new design, and the standard items were for the most part modified.

Figure 4 shows the layout of the rolling mill, and it should be noted that the mill mechanical equipment consists of the following:

1. A total of 14 roll stands, complete with gear reducers and pinion stands. The roll stands vary in

size from 20 to 10 in. and include one vertical 10-in. mill. The 20-in. roughing stand is 3-high, and all of the other mill stands are 2-high. These items make up the 4-stand in-line roughing train, a 4-stand intermediate continuous mill, a 4-stand cross country mill and a 2-stand continuous finishing mill.

2. The complete reheating furnace charging tables with disappearing stops and a double-ram, mechanically-driven furnace charger.
3. The furnace "peel" bar, which is mechanically driven.
4. An air-operated ingot turner.
5. The mill conveying tables, including one hydraulically-operated tilt table and billet manipulator, all located on the down side of the 20-in. mill stand.
6. The chain "drag-over" conveying table, located on the down side of No. 4 (14-in.) stand.
7. Four side sweep, Y-type, transfer tables serving the cross country mill stands.
8. Three air-operated, bottom escape-type repeaters (loopers) serving the cross country mill area. These repeaters may be shifted hydraulically when the section being rolled is to be transferred from stand to stand on the Y tables.
9. A 100-ton capacity hydraulically-operated hot crop and dividing shear, located on the down side of No. 4 stand.
10. A high-speed flying shear, located on the down side of No. 14 (10-in.) stand.
11. A 300-ton capacity cold bar shear, located between the hot bed discharge table and shear and gage table.
12. A complete 200-ft long mechanical shuffle-bar-type hot bed with runin and runout tables.
13. A 60-ft long gage table with electrically-operated gage head for fast positioning.
14. A 20-ton capacity recording weigh scale with bundling cradles for weighing of finished products.
15. Air-operated, electrically-actuated bar turners.
16. A complete automatic oil lubrication system for mill equipment.
17. A complete oil hydraulic system with tanks, pumps, etc., for hydraulically-operated equipment.

Total connected horsepower for the rolling mill including table drives is 6860 of which 3191 is d-c powered and 3669 is a-c powered. All the main drive motors were especially designed for steel mill service, and are of heavy-duty, steel-mill-type construction. Starting control of the main drive synchronous motors is from a metal-clad switchgear bank containing draw-out type air circuit breaker and synchronous motor field control compartments. The main drive d-c motors receive their power from a 2000-kw, 700-volt, d-c rectifier.

To attain high average production, the rolling mill delivers finished products to the hot bed at speeds varying from 785 to 2000 fpm, the speed depending on the size of the end product.

All of the equipment described has in one manner or other been installed in other mills. This same equipment utilized in proper relationship and provided with proper electrical drives and controls, as installed for the Lemont

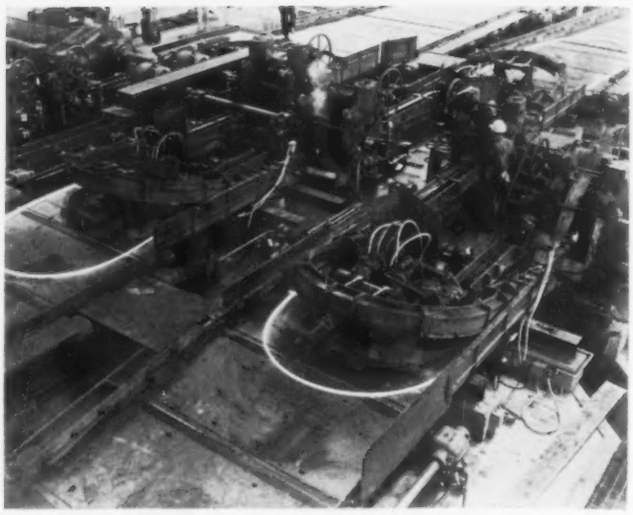


Figure 5 — Escapement-type repeaters are used on the cross country mill.

plant, makes this mill one of the most modern, highly mechanized reinforcing bar and merchant bar mills in the country.

The mill as well as the melt shop is supplied by industrial water from the canal. The water is pumped from the canal intake structure through an underground piping system into both the melt shop and the rolling mill. After having cooled the electric furnaces and the furnace transformers, the melt shop cooling water returns to the plant storm sewer system for direct discharge to the canal. The water system into the rolling mill conveys cooling water for the reheating furnace, for cooling the mill rolls and for removal of scale in the rolling mill flumes.

To eliminate the possibility of cooling water supply failure to the two critical items, the reheating furnace and the electric-arc furnaces, a 100,000-gal capacity, 70-ft high elevated water tank was erected. The altitude valve for this tank is designed to open in the event of power failure, and thus supply cooling water for the critical cooling period of the furnaces. Other solenoid-operated valves in the rolling mill cooling and flush water systems are designed to close in the event of power failure, thus reducing water consumption to the minimum.

Scale flumes were designed and constructed integrally with the mill foundations, so that scale from billets and bars drops into flumes and is washed into collecting basins. These collecting basins or scale pits are located outside of the mill foundations proper and are connected to the mill foundations by separate flumes. Scale flume flushing connections are installed at points such as the discharge to the reheating furnace, where large quantities of mill scale normally accumulate.

The two main scale pits are designed with sufficient spare pumping capacity, so that in the event of primary pump failure, secondary pumps will actuate by high-level float controls and prevent flooding of the mill equipment pits.

Because of Canal Authority regulations, effluent from the plant into the canal must be free of material which might settle in the canal and cause conditions hazardous to barge traffic. It is, therefore, necessary to pipe scale-laden water from the mill to a settling and skimming basin where small scale particles are removed.

The ingot reheating furnace was dried out in early August, 1959. A skeleton crew was then used to run trial bars through the roughing mill, and the first bar was produced in regular operations on August 25, 1959, working one crew eight hr.

The first day's production amounted to seven tons of No. 6 bar; the second day's 58 tons; the third day's 62 tons; the fourth day's 104 tons; with rapid increases thereafter. The mill was operated with one crew until October 19, 1959, when the crew was split, and filled in where necessary to operate the mill two turns per day, utilizing the graveyard shift for roll changes and maintenance work.

During the period from August 25 until October 19 attempts were made to roll every section required, to determine what problems would be encountered and to check roll design. Very little trouble was encountered with the roll design, and it was only necessary to make minor changes in order that the desired section be rolled. Several changes were made in the application of ingot sizes to obtain the optimum size to insure maximum tons per hr per section. Needless to say, there is still a good deal to be learned about the operation of this mill.

The mill consists chiefly of a semi-roughing train starting with a 20-in., 3-high stand and its auxiliary tilt tables and roller lines; two 16-in. and one 14-in. stand; and a runout table and a cropping shear. The ingots are rolled large end first; therefore, pipe is eliminated at the cropping shear. Small sizes then go through a 4-stand cross country 14-in. mill (Figure 5) and two 10-in. stand finishing. The cross country mill is serviced by repeaters as well as Y tables.

The large bars are transferred by means of a transfer table, after cropping, to a roller line and by-pass the 4-stand continuous mill. Thus almost any combination desired can be rolled, simply by taking out or adding passes as the section requires. The entire operation of the mill is controlled by operators in two air-conditioned pulpits, and the billets are never touched by the mill employees.

The ingots are charged in size according to the section rolled, and all sizes up to one in. are cut in multiples of 60 ft by a flying shear before delivery to the hot bed. The material from the cooling bed is cut to a standard 60-ft length and shipped as such. However, considerable tonnage is cut that goes directly to the job.

TABLE II
Monthly Production Figures

Month	Tonnage
1959	
August	283
September	3,108
October	5,675
November	4,744
December	4,272
1960	
January	9,123
February	10,234
March	10,617
April	10,008
May	10,976
June	9,894
July	10,890
August	11,000
September	11,400
October	12,200

Material is shipped from Lemont either by railroad, truck or by barge on the Chicago canal.

The production figures by months from August 9, 1959, to October, 1960, are given in Table II.

The record tonnage produced in any eight hr shift to date is given in Table III.

TABLE III
Mill Production

Product	Tons per hr	Product, in.	Tons per hr
No. 4 Bar	26	$^{27}/_{32}$ Plain round	40
No. 5 Bar	35	$^{25}/_{32}$ Plain round	40
No. 6 Bar	39	$^{23}/_{32}$ Plain round	30
No. 7 Bar	39	$^{21}/_{32}$ Plain round	30
No. 8 Bar	46	$^{19}/_{32}$ Plain round	29
No. 9 Bar	46	$1\frac{1}{2} \times 1\frac{1}{2} \times \frac{3}{16}$ Angles	27
No. 10 Bar	46	$1\frac{3}{4} \times 1\frac{3}{4} \times \frac{3}{16}$ Angles	37
No. 11 Bar	46	$2 \times 2 \times \frac{3}{16}$ Angles	39

Main plant power supply is fed by a direct tap line from a 132-kva transmission line. To provide transformation from a high-line voltage to usable plant voltages, a 10,000-kva transformer provides power for the rolling mill drives and all plant auxiliaries, while the 20,000-kva transformer feeds the three electric-arc furnace transformers.

Main plant switchgear (substation) is located in a weatherproof, metal housing immediately adjacent to the tranformer station, and power leads from the 10,000 and 20,000-kva transformers are connected to this switchgear by underground ducts. The direct-feed line from the switchgear to the electric furnace transformers was run in underground ducts to the rolling mill building, and was thence carried by conduits and cable trays to the melt shop. Leads from the main plant switchgear to other plant unit substations and rectifiers were handled in like manner, with the result that overhead pole lines with their attendant maintenance and operational problems were eliminated.

Although Ochiltree works is not located in a remote area, normal city water, sewage and fire protection services were not available at the plant site. A plentiful supply of drinking water was, however, made available by digging a 1500-ft deep well, chlorinating the water and providing sufficient water pressure by use of a 10,000-gal pressure tank. A complete sanitary sewage system including a sewage treatment plant was installed. Fire protection was provided by installation of a plant fire loop with water supply from one, 1000-gpm electrically-driven fire pump. To provide water in event of power failure, a 1000-gpm, gasoline-driven fire pump was installed, this pump is automatically started when the plant power is shut off.

Both the electric and the gasoline-driven fire pumps plus the three, 1800-gpm electric-driven plant cooling water pumps (one pump is a spare) are located over the intake well in the intake pump house. The intake well supplying screened water from the canal is 22 ft deep (in solid rock) and provides a sure source of water even when the canal is at its lowest possible level.

The intake pump house, like all other plant auxiliary buildings, is a flat-roofed concrete block, with brick veneer, structure. Other auxiliary buildings include a 3468-sq ft, air-conditioned, main plant office; a 3536-sq ft (220 men capacity) combination shower, locker and

first aid station building, plus such smaller structures as the gate house, the gas meter house, the deep well pump house and the sewage pump house.

The plant is serviced by 3½ miles of railroad siding and switch tracks. Ochiltree works has its own diesel-driven, 35-ton switch engine, two 25-ton capacity self-propelled railroad cranes; plus numerous gondola and flat cars for movement of scrap and finished products. A 50-ton capacity combination truck and railroad car weigh scale is installed in the scrap preparation area for checking in scrap and checking out finished products.

In addition to the above servicing facilities, a 600-ton, guillotine ram, hydraulic scrap shear was recently installed. This machine cuts unprepared scrap into useable lengths for charging into the electric furnaces. All operations are automatic from the time the scrap is dumped into the hopper, until it falls into a gondola car.

The arrangement of the melt shop, material flow, mill equipment and the rolling sequences are naturally a function of Ceco's needs. It was attempted to make the mill as flexible as possible and still be able to roll the wide range of products necessary with a minimum of roll changes and at a minimum cost. It is thought and experience to date indicates, that this mill is a good mill for the dollars invested, and it is felt that the production figures will substantiate this statement.

Discussion

PRESENTED BY

W. C. VOKOLEK, Vice President and Works Manager, Franklin Steel Div., Borg-Warner Corp., Franklin, Pa.

D. C. HORSMAN, Plant Superintendent, Continental Steel Co., Kokomo, Ind.

W. B. JACOBSEN, Works Manager, Ochiltree Works, Ceco Steel Products Corp., Lemont, Ill.

GEORGE SAEMS, Phoenix Manufacturing Co., Joliet, Ill.

G. R. CLARKE, General Superintendent, Laclede Steel Co., Alton, Ill.

F. T. HOKE, Roll Designer, Connors Steel Div., H. K. Porter Co., Inc., Birmingham, Ala.

E. C. PETERSON, Vice President, Rolling Mill Div., Birdsboro Corp., Birdsboro, Pa.

W. C. Vokolek: There are a number of operations in this country rolling a wide variety of bars and shapes on a single small mill from one or more types of raw material. The size of sections rolled is usually small. Many times the ordered quantity is not large. The justification for existence of these mills is by reason of their supplying not only some of the standard products of the larger steel companies but also special sections not commonly found throughout the industry and all with a maximum of quality and service.

In order to be competitive in the industry, such mills face two major problems: one is costs, because labor rates generally parallel those throughout the industry, and the other is the necessity for flexibility. Frequent changes in operating schedules and greater manpower requirements for special sections makes automation in the average small mill a more difficult problem than in the heavy producing unit. Of necessity, the operating personnel are resourceful and are constantly striving for increased efficiency.

The Ceco mill at Lemont is a good illustration of a project starting from scratch wherein operating and engineering know-how were combined to attain output goals at the lowest possible cost, yet retaining some of the flexibility with which the small mill must live.

D. C. Horsman: In approaching the matter of purifying the water that is put back into the canal, is there a state specification which regulates the parts per million of impurities that can be put into the canal? If so, how is the water checked for contained solids and how often are the results checked?

W. B. Jacobsen: The regulations only require that clear water be returned to the system, and that is what is done.

George Saems: Were there any problems in rolling the ingot, large end first; is it just good rolling practice or is it done out of necessity?

W. B Jacobsen: The big end is rolled first to facilitate manipulation on return to the second pass, taking advantage of the natural taper; also, this permits the proper end to be delivered to the crop shear for pipe removal.

George Saems: With the 12-in. continuous rougher, you break down with a 12-in. roughing train and then go to a 14-in. cross country. The pitch of these mills is in reverse. Is the advantage of the 14-in. pitch lost?

W. B. Jacobsen: The 4-stand continuous rougher is only used in rolling small bars like Nos. 3, 4 and 5, and a square out of the No. 8 stand or a square out of No. 4 stand can be used for repeating purposes. The 14-in. cross country mill is for the rolling of large sections, when the continuous mill is not used. The bars which go through the 4-stand mill are actually smaller, and there is no particular trouble nor any lost efficiency on the line. As a matter of fact, the larger rolls help pick up any slack that may develop.

George Saems: How large an angle is repeated? Is there a variation in leg lengths, when repeating?

W. B. Jacobsen: Angles up to and including two in. are repeated. Since starting repeating there is less variation in the section than before; the bar finishes hotter and better control of the bar is obtained between passes. A better angle is rolled by repeating and much less horsepower is used.

G. R. Clarke: What cross-sectional size of ingot is used and what is its weight?

W. B. Jacobsen: Originally there were three sizes of ingot: 5 x 4 in., 6 x 5 in. and 8 x 7 in. with two lengths of each, or two weights of each. It was felt that the small ingots would be used for the small sections. Now by use of better roll design and better timing, the large ingots can be used for the small sections, utilizing the flying shears for proper hot bed cutting. Thus more tons per hr and a much higher yield are obtained. Basically, the 1000-lb, the 820-lb and the 470-lb ingots of an approxi-

mate 8 x 7-in. cross section are in use.

F. T. Hoke: The primary reason for rolling an ingot directly into the finished merchant bar section is the elimination of the initial cost and overhead cost of the blooming mill.

There are two merchant bar mills at Connors, both of which roll billet-size ingots directly into the finished product. Not having flying shears makes it necessary to use seven ingot sizes to obtain the required hot bed lengths for a standard range of merchant bar sections.

The process of continuous casting would eliminate the blooming mill and also the numerous billet-size ingots. Was this method considered in planning the mill?

W. B. Jacobsen: Since the experimentation with direct billet casting was still in its infancy, it was felt that there were no funds available for experimenting with billet castings.

This mill was a joint venture and the engineering firm and the various suppliers did a good job. Excavation was started, the mill put up and a few tons rolled without any argument along the line. There was good teamwork and it is certainly appreciated.

E. C. Peterson: The question of direct rolling vs double conversion of bar and merchant mill products is one which excites a great deal of interest today. The economics are far from being established and it is not unusual to see companies moving in opposite directions at the same time.

The oldest direct rolling units in this country today are probably the numerous rail slitters who have installed electric furnaces and produced billet ingots to augment the diminishing supply of rails. Several of these rail slitters, whose problem is involved in the necessity of continuing to slit rails, are improving their rolling conditions by mechanizing their roughers and by applying repeaters at various points.

In addition to these rail slitters, there are several semi-integrated units, direct rolling billet-size ingots only. For the most part, these plants are using simple hand mills, some new, some secondhand.

The mill at Ochiltree works represents the first modern, high-speed, fully mechanized mill to be constructed specifically for the purpose of direct rolling billet-size ingots; therefore, it represents a "coming of age" of the direct rolling operation.

On the other hand, a used mill is being converted to a modern, reversing blooming mill for a plant which is now direct rolling, but which will commence double conversion in the interests of over-all production economy. There are other direct rollers who are considering the installation of double conversion facilities.

Some of the factors which affect these conflicting trends are:

1. The extra cost of producing small ingots, which must be weighed against the economies of direct rolling.
2. There are some specialty products which require intermediate conditioning to meet quality specifications, and any mill wishing to produce these products will have to consider double conversion.
3. Increasing freight costs give specific advantages to steel producing operations located in isolated markets. However, the markets of these places are generally too small to support large producing units. Therefore, the relatively low capital cost of a direct rolling operation is of interest.
4. The difficulty of obtaining finished steel when business is good has induced several independent fabricators to put in mills of their own. Apparently billet prices are not set at attractive levels by integrated steel producers. In fact, as far as is known only one unit is rolling from purchased billets. Thus, such a fabricator is more or less obliged to produce billets, and in order to keep his capital investment in line with his relatively small production requirements, he usually considers direct rolling the best answer.

It would be interesting to hear further of the various aspects of this problem. Men who have had considerable experience in both types of production could do much to clarify the reasons for the existence, side by side, of these two radically different types of production. ▲

RESERVE THESE DATES

1962 AISE NATIONAL MEETINGS

SPRING CONFERENCE—APRIL 30, MAY 1, 2
Sheraton-Cadillac Hotel, Detroit, Mich.
Inspection trip to Great Lakes Steel Corp.

WESTERN MEETING—JUNE 4, 5, 6
Antlers Hotel, Colorado Springs, Colo.
Inspection trip to Pueblo Plant, The Colorado Fuel & Iron Corp.

ANNUAL CONVENTION AND IRON AND STEEL EXPOSITION
SEPTEMBER 25, 26, 27, 28
Cleveland Public Auditorium, Cleveland, Ohio
Social activities at the Statler-Hilton

The Power Distribution System of an integrated steel plant

by DONALD STEWART, JR.
Electrical Maintenance Engineer
Electrical Maintenance Dept.
Kaiser Steel Corp.
Fontana, Calif.

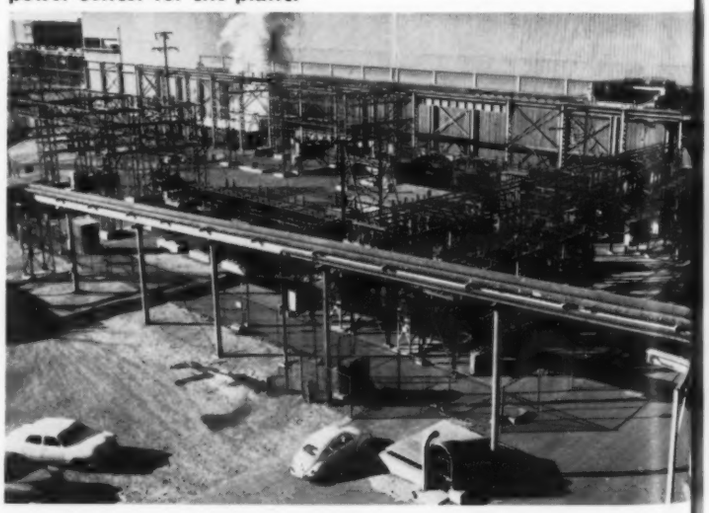
. . . . improved power distribution circuits and a load-compensating, voltage-controlling system, using two large synchronous motors, are combined to reduce voltage fluctuations caused by varying loads of the rolling mills, which must be controlled to permit a steady demand when added to the other plant loads. All control is affected by the well-regulated utility power supply . . . .

THE purpose of this article is to describe the power distribution system of an integrated steel plant, and explain how this system and the fluctuating loads in a steel plant are related to each other. The power distribution system on which this article is based is that at the Fontana works of the Kaiser Steel Corp. The article is divided into three sections: (1) a description of the power system at Fontana; (2) a description of the factors which create or accentuate the problems due to the fluctuating loads at the Fontana plant; and (3) the remedial and preventive actions that have been taken to alleviate the fluctuating load problem.

DISTRIBUTION SYSTEM AND PLANT LOADS

The system of distribution at the Fontana plant is basically a dual-radial system with secondary or remote load selectivity for all except the least important load centers. All of the plant power is furnished by the Southern California Edison Co. over three 67,000-volt lines to the main power centers. The first of the main power centers, the rolling substation, a 70,000-kva self-cooled, 93,000-kva fan-cooled, 67 to 6.9-kv station (Figure 1) has a dual low-voltage bus with a bus tie breaker between bus halves, and parallel feeders to the main 6900-volt load centers in the west and central parts of the plant from each bus half. The second center, the

Figure 1 — The rolling substation was the original main power center for the plant.



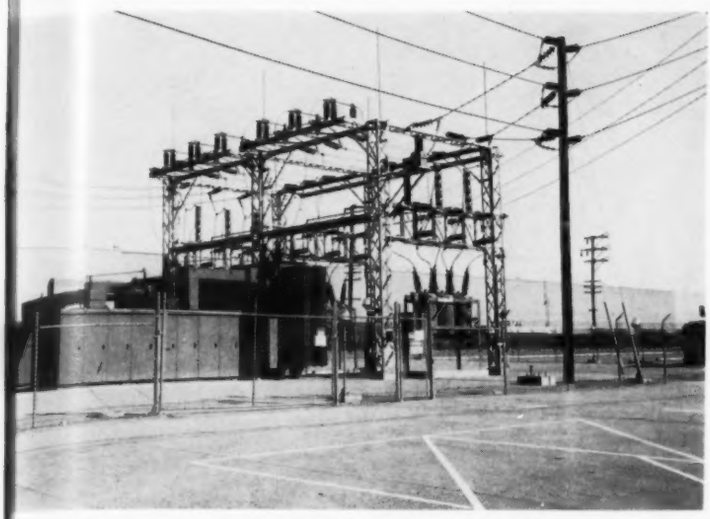
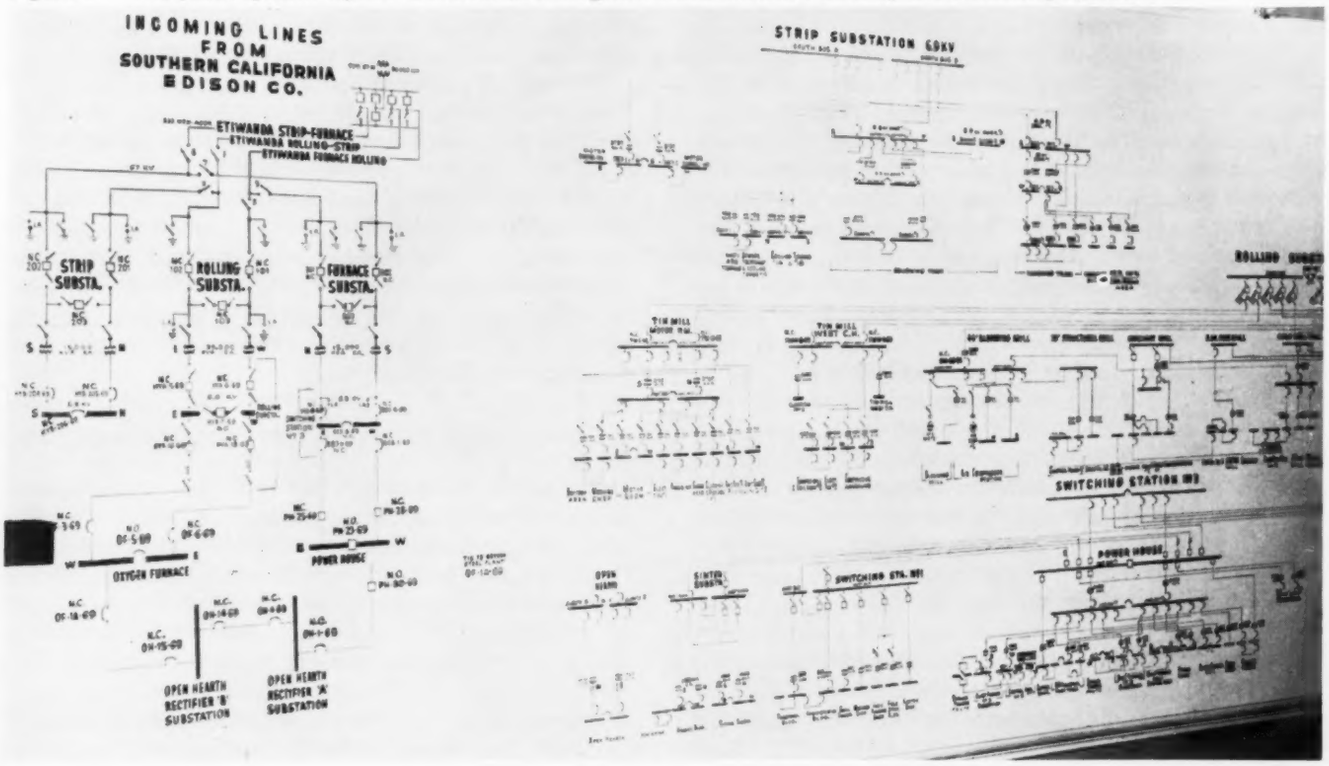


Figure 2 — In 1956 additional load capacity was required, and two 30,000-kva substations were installed.

strip substation, a 30,000-kva self-cooled, 40,000-kva fan-cooled, 67 to 6.9-kv station (Figure 2) has a dual low-voltage bus with bus tie breaker and parallel feeders to the hot strip mill and nearby cooling-water pumping plants in the south part of the plant. The third center, the furnace substation, another 30,000-kva self-cooled, 40,000-kva fan-cooled, 67 to 6.9-kv station, has a dual low-voltage bus with bus tie breaker, and parallel feeders to various load centers in the north and east parts of the plant. Lower voltage busses are generally arranged dually, with a bus tie and a separate transformer or feeder supplying each half of the bus from opposite halves of another dual bus. In the original design of the power distribution system of the plant, the necessity of providing a reliable power supply to the iron and steel producing areas of the plant was strongly felt because electric power failure of more than a few minutes duration in these areas could cause serious damage to a blast furnace or an open hearth furnace. This system of distribution, which at the plant's beginning was applied only in the iron and steel producing areas of the plant, has been extended into existing load areas which originally had only a single radial feeder supplying power. The dual system has also been applied to almost all load centers for production machinery for new facilities which have been added to the plant as it has expanded, in order to provide a reliable and reasonably simple power system consistent with installation cost. This system of distribution has had a beneficial effect on fluctuating-load problems. Figure 3 illustrates the 1-line diagram board used by the plant switching operator and shows how fully the system is dual radial.

The expansion of the Fontana plant has proceeded almost continuously since the plant started in 1942, and the power distribution system, of course, has had to expand in proportion to the plant size. In 1952 when the tin plate mill was installed, the connected load increased so much that the existing system power distribution center was replaced by a completely new power center, as the currents required by the tin mill connected load would have substantially overloaded the old power center. The new power center was the 6900-volt busses and switchgear of the rolling substation, shown in the right side in Figure 1. Before 1952 the rolling substation contained only 67-kv busses and gear, and 67 to 6.9-kv transformers. This replacement of the main 6.9-kv power center for the plant with a new one eliminated what would have been impossible load problems, but caused other load problems because of the insertion of line current limiting reactors in the feeders from the new main power center. The older switchgear in the original load centers did not have sufficient interrupting

Figure 3 — The plant system layout is shown on a diagram board which is used by the switching operator.



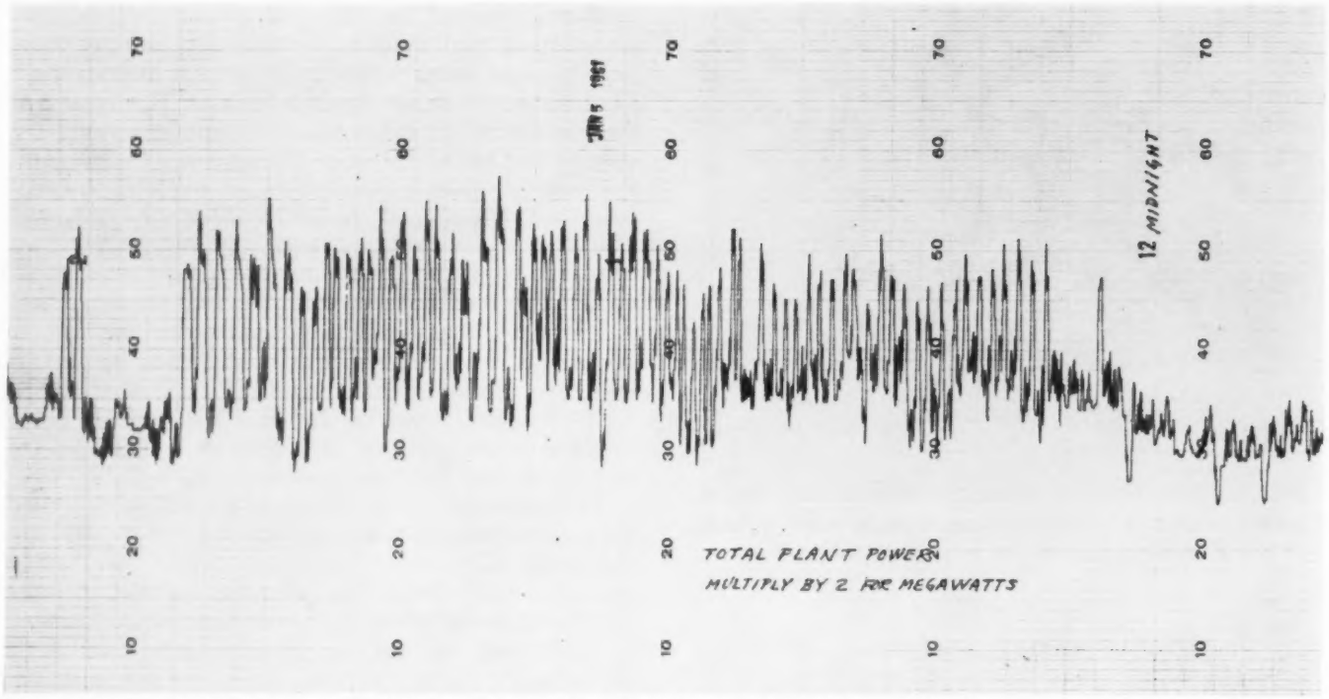


Figure 4 — The instantaneous plant demand is greatly affected by the hot strip mill load.

capacity for the size transformer banks installed at that time.

In 1956, when the most recent expansion required so much additional connected load, any increase in transformer capacity at the rolling substation would have created short circuit capacity beyond the rating of available gear and would have required long, very heavy cables to the new load centers. Therefore, two new main power centers, the strip substation and the furnace substation, were established near the centers of existing and new loads. Existing and new loads near the furnace substation were connected to it, relieving the rolling substation for new loads near to it.

The distribution voltage for the plant is nominally 6900 volts, and power is delivered at this voltage to distribution transformers in a range of 50 to 3750 kva and motor loads in a range of 1000 to 9000 hp. There are certain areas throughout the plant which require a distribution voltage of 2300 volts for medium-sized motors in the range of 200 to 1500 hp. The remainder of the 3-phase motor load in the range of ⅓ to 400 hp is served at 460 volts. The power rectifiers at the plant, which are in the range of 500 to 5000 kw are served at 2300 to 6900 volts. All 6900 and 2300-volt power distribution is done with underground cable in ducts, or trays in tunnels. The lines from the main power centers to the loads with the greatest fluctuation are physically fairly short. The short circuit current-limiting reactors between the rolling substation and the load centers with limited interrupting capability gear have a five per cent impedance on a 24,000-kva base, and perceptibly increased the voltage regulation for load centers with very large load swings as certain of the rolling mills have.

The various types of loads in a steel mill may vary in stability of demand from something as constant as the load of an incandescent lamp bulb to something as variable as the load of an arc furnace during the melting cycle. It is characteristic of the large metal rolling mills in a steel plant that the instantaneous power demand of one individual mill may vary through a range as high as 100 to 1 in a cycle time as short as four sec. With the 46-in. blooming and slabbing mill, in particular, the load on the main mill motor can be 250 per cent for two sec and 2½ per cent for two sec, and then repeat. Another mill with an extremely fluctuating load is the 86-in. hot strip mill with a finishing train load which may have a demand of 110 per cent for 60 sec and 3 per cent for 10 sec, and repeat. Loads like these would create serious voltage problems if consideration of these variable loads had not been taken into account in the original design, or later steps taken after the original installation to counteract the effects of these loads.

The rate of rise of instantaneous demand on some of the mills is also very high, i.e., the 86-in. hot strip mill finishing train load may go from 1000 to 22,000 kw in seven sec. The rate of load rise on this mill is so rapid and the range so large that the voltage drop that would be created must be reduced by high-speed voltage-regulating methods using synchronous machines rather than slow transformer tap-changing methods. Figure 4 shows a portion of the record of total plant instantaneous demand, with the hot strip finishing train load peaks plainly showing.

PROBLEMS RELATED TO FLUCTUATING LOADS

The problems associated with the plant power system which are accentuated by fluctuating loads, in reality have been, and are, few in number because of efforts by the plant designers, the plant electrical maintenance dept. and the Southern California Edison Co. to prevent or eliminate them. However, one possible problem which always must be borne in mind at the plant before unusual power distribution situations are created by switching is the low voltage which may be created by the large fluctuating loads. Some effects of low voltage

on the loads fed by a power system are poor operation of resistance-type heaters, low or flickering output of incandescent lamps, failure to ignite of mercury vapor lamps, reduction of torque capabilities of a-c motors, variation in output voltage of power rectifiers and inconsistent or unsatisfactory operation of voltage-sensitive electronic apparatus. Low-voltage conditions at the plant have not been a problem for most of these types of loads for various reasons. The single important resistance heater, the heating elements in certain of the zones of the annealing furnace in the tin mill continuous annealing line, is fed by distribution circuitry which has a nominal amount of impedance in series with it and other large fluctuating loads. Lighting load circuits are arranged so that critical lighting loads are fed from busses that do not have voltage variations large or frequent enough to be classed as flicker and any noncritical lighting loads are not disturbed by intermittent moderately low voltage. Voltage-sensitive electronic apparatus at the plant either has had voltage-stabilizing devices installed with the apparatus or voltage-stabilizing devices have been later added where it was found to be necessary.

The possible problem of communication interference caused by the fluctuating mercury arc rectifier load was recognized when the rectifiers were installed and closely investigated as soon as the rectifiers went into service, but care was taken in the design of the rectifier installations so that the total rectifier load is reasonably well balanced 12 phase. So far harmonic interference in communication circuits from rectifier load has not been severe enough to require any extensive corrective action.

The loads at the Fontana plant that have been a problem because of a reduction in a-c voltage are the large synchronous or induction motors which drive motor-generator sets furnishing d-c power to main mill motors, and the large power rectifiers furnishing d-c power to main mill motors. The peak torque demand on the motors for certain of the motor-generator sets is very high, frequently approaching pullout torque, because of the type of intermittent peak load that a rolling mill places on its electrical driving machinery. If the a-c voltage applied to the terminals of these motor-generator set drive motors falls too low, the synchronous motors will pull out of step on peak load, and stop. The induction motors will drop so low in speed that they will draw excessive line current and the generators they drive will not maintain voltage. Both these situations have occurred at the Fontana plant in the past. In the case of power rectifiers, excessive fluctuations in a-c voltage applied to the rectifier will cause reduction on the output voltage of the rectifier, particularly if the a-c voltage reduction occurs at the same time as a very heavy load on the rectifier. The voltage drop internal to the rectifier adds to the drop in voltage applied to the rectifier, and the rectifier voltage-regulating system runs out of its range and cannot maintain a constant d-c output voltage. In the past this situation has been a problem on two mills where the mill drive motors were fed by large power rectifiers and had to run at substantially constant speed.

A power distribution problem which creates operational difficulties similar in nature to those produced by low distribution voltage due to large, fluctuating loads, but much more severe in degree, is distribution system

Figure 5 — Underground distribution is favored for the main power circuits.

short circuiting. Of course, when a short circuit occurs, any operation getting power from the shorted circuit is stopped completely for varying lengths of time.

Another problem that is a result of fluctuating load, although not in the same way as low voltage, is the problem of keeping the plant load factor high in order to keep the cost of energy as low as possibly consistent with the costs incurred in keeping the load factor high. The cost of energy is based partially on the maximum average rate at which energy is used averaged over any specified 30-min period within the billing period. This rate must be held to as low a figure as is economically possible. The problem of maintaining a high load factor is continuously with the Fontana plant and forms a problem in two distinct areas. The first area is the problem of planning the operation to produce a high load factor, and the second is the problem of maintaining a high load factor when it is impossible to plan the load as closely as is necessary in order to produce a given minimum load factor. The methods used at the Fontana plant in attempting to arrive at a solution of the problem in these two areas is described later.

PREVENTIVE AND REMEDIAL SOLUTIONS TO FLUCTUATING LOAD PROBLEMS

The methods that have been adopted through the years at the Fontana plant for coping with the problems of a fluctuating electrical load and related problems have been both preventive and corrective. The effects of poor voltage regulation were considered by the plant designers since the start of the plant, and several of the design ideas that have been consistently used at the plant fall in the class of preventive methods and have been an important factor in minimizing the problems associated with poor voltage. The dual-radial system of distribution has lowered the voltage spread because each half of a dual-radial feed in general is only half loaded so that in an emergency one half of the dual feed can carry the whole load to a given area. The half-

loaded feeders reduce voltage spread to one half what it would be from a single-feed design.

Another general design principle that has favored good voltage regulation is the use of underground cable in ducts or tunnels rather than overhead open wire lines for main power distribution circuits. There are no Kaiser-owned open wire distribution circuits at Fontana so that the higher line reactance of an open wire line as compared to an underground cable line has not complicated voltage regulation problems at the plant. Figure 5 shows the cable tunnel from the strip substation to the hot strip mill, as an example of distribution system wiring methods.

The use of load centers for the transformation of primary distribution voltage to the secondary utilization voltage, besides costing less for original installation, has helped to reduce voltage spread. The transformers at the plant which serve general 460-volt loads are in the range of 112.5 to 2000 kva with an average of only 882 kva. The load centers reduce long secondary runs and the voltage drop associated with them. Figures 6 and 7 show examples of the load centers used throughout the plant.

The line-start motor, at the plant, with the highest starting current is a 350-hp, 440-volt motor. This motor is in a part of the plant where the large voltage dip during starting of the motor causes no continuous, large-scale problems. However, the average full-load current of 6.9 and 2.3-kv line-start motors is only 86 amp. Furthermore, most of the 2.3-kv line-start motors are connected to motor busses which feed no loads other than motors. For these reasons, voltage dips due to motor starting, while not eliminated, are appreciably reduced.

Another general design principle that has helped to reduce voltage fluctuation, in addition to permitting maintenance of an average 95 per cent plant power factor, is the liberal application of synchronous motors on many of the busses throughout the plant. As the voltage at a bus tends to rise or fall, the synchronous motors on the bus will absorb or supply magnetizing vars and counteract the change in bus voltage. Of all the plant connected horsepower on 6.9 or 2.3-kv busses, 59.5 per cent is synchronous.

The worst low-voltage condition the plant has experienced was produced by the most extreme fluctuating load that the plant has experienced for any length of time, and that is the hot strip mill finishing train load. Original power distribution circuitry for the hot strip mill busses was from the rolling substation with its feeder current-limiting reactors, and these regulators were between the original hot strip mill busses and most of the plant synchronous motors. Upon initial startup of the hot strip mill in its original location, it was realized that the regulation of the plant voltage, with the fluctuating hot strip mill finishing train load, would be a problem. The two things that considerably reduced plant voltage regulation due to the hot strip finishing train load with its original circuitry were the location of a stable voltage supply near the Fontana plant with heavy lines to Fontana from this power supply, and the installation of a load-compensating, voltage-controlling system at the plant. The stable voltage supply which has furnished the plant a well regulated source of 67,000 volts is the Southern California Edison's Etiwanda steam plant which has a large capacity bus, and is only two miles from the Fontana plant. The load-compensating, voltage-control system was a system by which the field excitation to two 8200-hp, 6900-volt synchronous motors in the tin mill was increased in direct proportion to the 6900-volt load current going to the 86-in. hot strip finishing train up to the motor thermal limit point. When the strip mill loaded up, the 8200-hp motors furnished a substantial portion of the reactive kva required by the loaded power rectifiers for the 86-in. mill without increasing the motor terminal voltage or motor field current excessively, thereby offsetting the reactive voltage drop through the rolling substation transformer banks. The well-regulated plant power supply together with the load-compensating, voltage-controlling system at the plant reduced regulation on the hot strip mill busses from the value it had for several months, eight per cent to approximately four per cent for the average maximum load.

Improved power distribution circuitry to the hot strip mill, which was established in 1956 and 1957,

Figure 6 — Synchronous motors are connected to the busses to reduce voltage fluctuation.

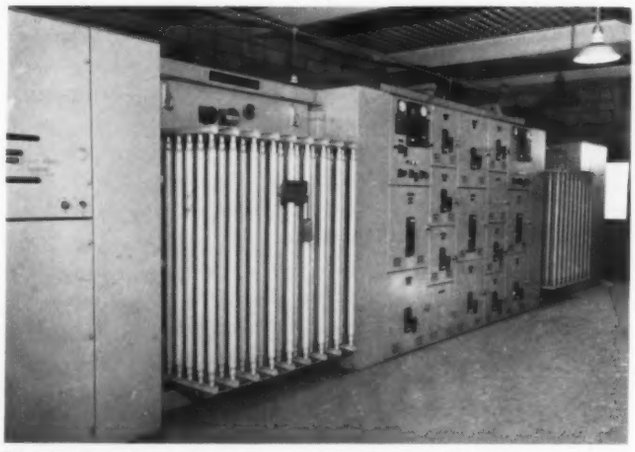


Figure 7 — Load centers are spaced within the plant to serve various localities.

Figure 8 — Plant instantaneous load is indicated at the plant control center.

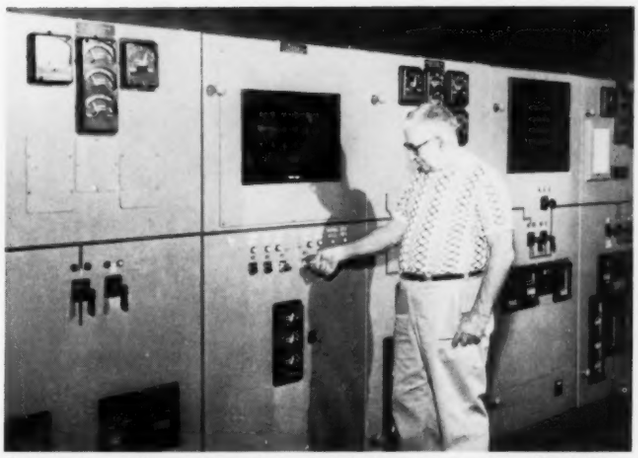


Figure 9 — When the plant load rises above specified limits, the switching operator must signal one or more of the mills to stop rolling.

when the 6-stand, 86-in. finishing train was moved from its original location to another part of the plant, and preceded by a new 5-stand roughing train, has further reduced problems of voltage fluctuation from rapid and large finishing train load fluctuation. Though the strip substation which feeds the finishing train is only 30,000 kva, 29,000 hp of the roughing train mill motors fed from the same substation are synchronous, so that the 6900-volt bus voltages in the strip mill are held quite stable, and fluctuations of load to the finishing train just as large as those with the former power distribution circuitry produce only a 3-per cent change in the 6900-volt bus voltage for the strip mill power rectifiers.

The operational difficulties created by a-c power-distribution short circuits have been somewhat of a problem in the past in one area of the circuitry at Fontana, but good design and maintenance have either prevented by design, or remedied by maintenance any continuing problem. All the plant 6.9-kv cable is rated for either 15 or 11-kv grounded neutral circuits. The 2.3-kv cable is rated for 5-kv ungrounded neutral circuits. Care was taken during installation to use the best practices on pulling in, splicing and terminating cables. A system of measuring the insulation resistance of cables, transformer windings and transformer and circuit breaker oil is in practice at the plant. The one area which was a serious problem was the flashover of insulators for the 67-kv busses in the rolling substation caused by insulator contamination coupled with heavy fogs. Insulator cleaning was done with rather high frequency, but was expensive and always somewhat hazardous. Even with all the cleaning, flashovers were all too frequent, and a large area of the plant was affected by the drop in voltage. To attempt a more permanent solution to the problem, silicone grease was applied to all the 67-kv insulators and bushings in the substation. Although to the eye the insulators look extremely contaminated, the silicone grease rejects the moisture in the fogs and mists, from the surface of the porcelain. Since adoption of this practice several years ago there has not been one flashover, and time between insulator cleanings has been increased eight to nine times. Furthermore, the effort involved in cleaning the insulators is considerably less, as the contamination comes off with a rag rather than with steel wool.

The other area besides plant voltage regulation in which fluctuating load has caused a problem is the area of control of plant load factor. There is, of course, nothing that can be done in the way of electrical design and installation that could give the plant a high load factor. It is an operational problem and an operational solution has been devised. The operating schedules for each unit are planned so that high electrical load periods will be as short, as few and of the minimum magnitude possible. However, the operating units that can be scheduled either on or off are not always the correct load size, nor is the electrical load of each operating unit a fixed quantity, but it is dependent on many controllable and noncontrollable factors. In addition, an attempt to schedule the plant operation purely with the idea of having the highest possible load factor would produce operating schedules unsatisfactory in other ways. Therefore, the schedule for the various plant units is somewhat of a compromise as far as attempting to produce a very high load factor. The schedule for the various units of the plant is arranged so that except for two to ten 8-hr shifts per month, depending upon the rate of operations at the plant, there is always one major load unit scheduled to be nonoperative.

For the two to ten shifts per month when scheduling cannot be arranged to limit the load, it is necessary to keep a watch on the rate at which the plant is using energy during all energy demand periods, and attempt to limit the rate to a specified quantity by stopping certain loads before the end of the demand period for a time long enough so that the averaged power at the end of the demand period will be the specified limit, neither higher nor lower. This demand limiting is a skill that grows with practice. An indication of the success of scheduling and demand limiting in raising the load factor is the average load factor of 65.2 per cent. Figures 8 and 9 show, respectively, the control center where the total plant power is indicated and recorded, and a switching operator signalling one of the mills to stop rolling to limit the plant demand.

In retrospect, the plant power distribution system has been described as a background for the plant's distribution problems. The things about the system which have affected or still occasionally affect the operation, and some of the methods and designs which have largely, except for very unusual situations, solved these problems have been discussed. ▲

Figure 1 — View shows the Azovstal works in Zhdanov, Ukrainian SSR, from the central entrance.

Development of USSR Iron and Steel Industry—II

by IVAN DENISENKO, Economist, Economic Research Institute,

and ROMAN BELAN, Metallurgical Engineer, Head, Iron and Steel Industry Dept., State Planning Commission, USSR

. . . . the original paper was published in the September, 1961, Iron and Steel Engineer *without the discussion and figures which had not been received at that time. This material is now available and follows. In addition, a supplement which incorporates the latest Russian changes in planning and accomplishments, brings the paper up to date.*

It is also interesting to note that the USSR emphasizes that it is basing its long-range development plan on steel products and not on the nonferrous or nonmetallic items sometimes considered as competitors for steel in the future . . . .

IVAN DENISENKO

ROMAN BELAN

THIS article provides a brief outline of recent developments in the Soviet iron and steel industry.

The following supplements the report delivered at the Annual Convention of the Association of Iron and Steel Engineers in the U. S. in September, 1960. Over a year and a half has passed since the time of the report, and important changes have meanwhile taken place in the development of the USSR's iron and steel industry. These changes apply both to the factual data on the production of iron and steel in the recent

Figure 2 — The quarry of the Mikhailovsky iron ore mill in Kursk region. The rotor excavator has a capacity of 18,000 cu ft per hr, and a conveyor installation 1¼ miles long.

wo years and to the plans that have been drafted for he years to come.

The article deals with the prospects of the development of the iron and steel industry in connection with the implementation of the Soviet Union's 7-Year Economic Development Plan for 1959 to 1965.

The successful realization of this plan means an ever-increasing demand for iron and steel. The first two years of the 7-year period have seen the construction and commissioning of over 2000 major industrial enterprises, over 7000 miles of railway tracks and highways, the erection of residential houses with a floor space totalling 1,750,000,000 sq ft, as well as of a large number of schools, hospitals, crèches, kindergartens and other buildings, cultural and public service establishments. The gross industrial output has increased by 23 per cent. Naturally, such an upsurge of the entire economy would have been quite unthinkable without an accelerated development of the iron and steel industry.

In 1960 the USSR produced 51,300,000 net tons of cast iron, 71,600,000 tons of steel and 56,000,000 tons of rolled metal, including 6,370,000 tons of steel pipe. As in the foregoing year, the rate of increase of iron and steel production has surpassed the rate envisaged by the 7-year plan.

In 1961 steel output will reach approximately 78,500,000 net tons; cast-iron output, 56,500,000 tons; and rolled products, 61,000,000 tons.

The results of the first two years of the 7-year plan and in 1961 confirm the data cited in the report that in 1965 steel output in the USSR would reach approximately 110,000,000 net tons.

Parallel with a growth of metal production the Soviet iron and steel industry has undergone important qualitative changes.

In the course of the past two years progressive technology was being introduced on a large scale at Soviet iron and steel enterprises. About 85 per cent of all blast furnace volume is now operated at higher gas pressure at the furnace top. In 1960 some 41.3 per cent of the total cast-iron output was produced with the use of natural gas, while steel produced with the application of oxygen covered 28.1 per cent of the total steel output.

The year 1960 saw further improvements in the utilization of blast and open hearth furnaces. There was 24.2 cu ft of useful blast furnace volume per net ton of cast iron produced per day (efficiency of useful volume) while the mean daily yield of steel per sq ft of open hearth furnace area was 0.65 net tons, as against 0.634 tons in 1959.

Among the most important recent events in the development of the country's economy and culture was the drafting of the plan of economic development for the 20 years to come (1961 to 1980). The chief economic target of this plan is the creation of a material and technical foundation for communism. Its implementation will serve as basis for such a development of industry and agriculture that will permit meeting the demands of USSR's society and of every one of its members.

The coming ten years will see a 250-per cent increase in gross industrial output, and the increase for the twenty years to come is to be no less than sixfold. The

Figure 3 — One of the shops at the Krivoy-Rog Mining and Dressing works, Ukrainian SSR.

steady growth of metal production remains one of the most important economic targets, since iron and steel will remain for many years ahead the chief structural materials, in spite of the fact that aluminum, titanium, synthetic materials will be finding ever-increasing application in the manufacture of machines, instruments and equipment.

Under the long-term plan the USSR's iron and steel industry is to attain in the course of the 20 years a level of development that will make it possible to produce approximately 275,000,000 net tons of steel per year. That is almost four times as much as had been produced in 1960. Steel output will have to meet fully the ever-increasing demands of the national economy, in conformance with the technical level that will be achieved by that time.

The output of cast iron, rolled metal, pipe and other iron and steel items is to increase correspondingly.

It is rather difficult to imagine in detail what a Soviet iron and steel plant will look like 15 to 20 years from now. We may already say that blast furnaces by that time will probably have a volume of 88,000 to 95,000 cu ft and will operate at 37-psi top gas pressure and at 2150-F blast temperature.

Figure 4 — Blast furnace shop at the iron and steel works in Krivoy-Rog, Ukrainian SSR, is a major producer.

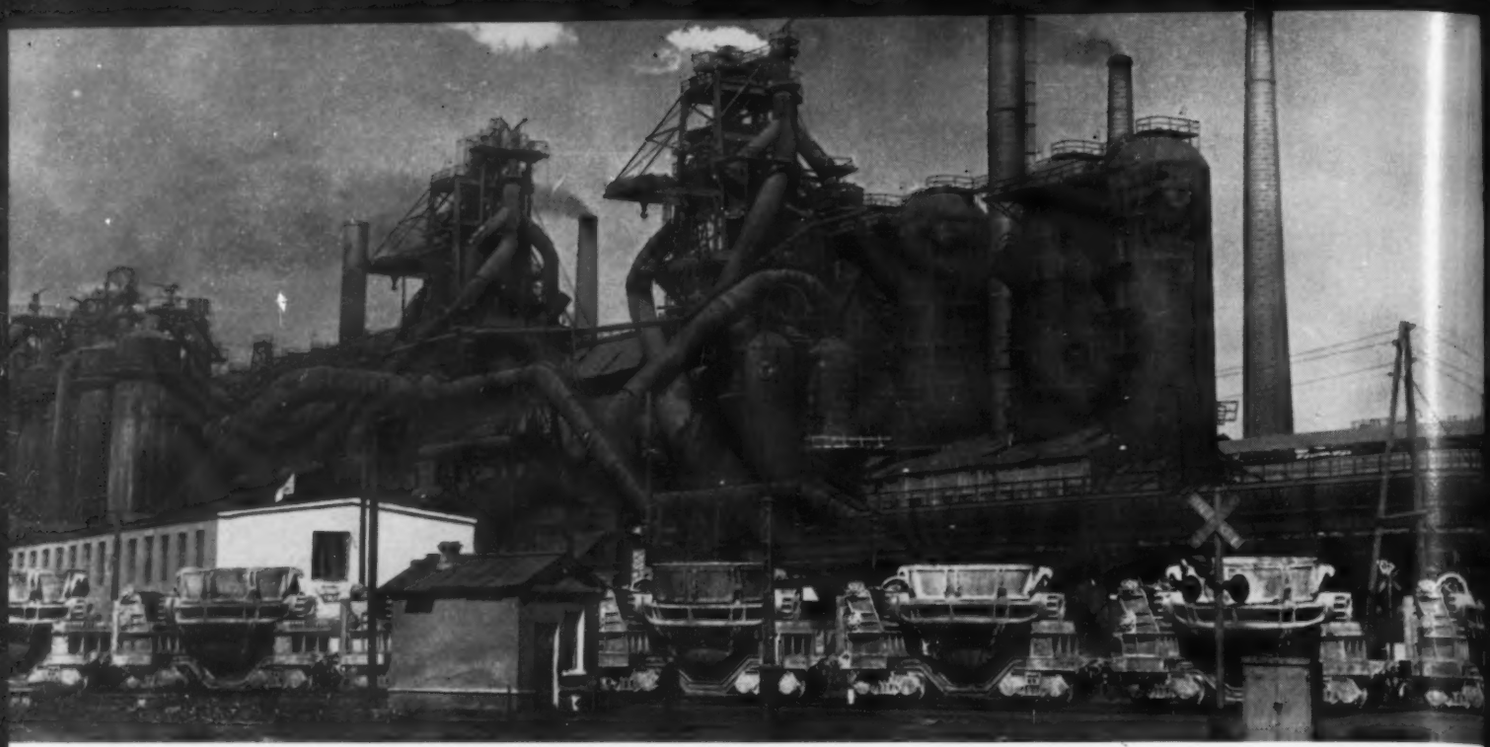


Figure 5 — Blast furnaces of the Magnitogorsk Iron and Steel works.

The blast furnace charge will be prepared and separated into fractions with partially reduced iron. Extensive use will be made of oxygen and natural gas.

Open hearth furnaces will be built with capacities of 660 to 1000 tons; converter and electric furnaces with capacities of 110 to 330 tons. In the ten years to come the average capacity of open hearth furnaces is to be doubled, and that of converter and electric furnaces increased approximately sevenfold. The development of the converter method of steelmaking with the application of oxygen will be given priority. There will also be an increase in the output of electric steels, and the share of open hearth steel in total steel manufacture will decrease considerably.

The output of hot-rolled metal will be growing at a faster rate than steel manufacture, since the introduction of continuous steel teeming and other improvements will cut down sharply the input of steel per ton of rolled metal. Extended use of pipe parts, elements, units and structures will call for the rapid development of the manufacture of pipe, electrowelded and welded pipe in particular.

It is planned to improve considerably the qualitative characteristics of metal, to enlarge the production of alloy and low-alloy steels. Parallel with an enlargement of the assortment of shaped rolled stock, there is to be an increase in the output of bent profiles of sheet steel, part of the shaped metal being substituted by welded structures of sheet and pipe. Hot-rolled sheets will be replaced by cold-rolled ones, and rod by wire.

Figure 6 — The blast furnace shop at the Karaganda Iron and Steel works in Temir-Tau, Kazakh SSR, is shown under construction.

Sheet rolling will be considerably increased. In the near future flat products will cover 40 per cent of the total rolled stock, over a half of it being thin-sheet steel. The output of tin, transformer and dynamo steel is to grow many times.

The greater part of metal goods are known to wear out due to atmospheric corrosion. It is planned to organize the output of large quantities of metal with protective varnish, paint, plastic, zinc and other coatings, so as to prolong the metal's service life.

In order to provide for the output of 275,000,000 tons of steel a year, the production of iron ore will have to be increased in the course of the 20 years to reach no less than 440,000,000 tons of commercial ore per year. The great mineral wealth of the country provides opportunities to solve this problem successfully. The Soviet Union possesses practically unlimited resources of iron ore. According to the latest data, the prospected stock of iron ore amounts to 47,000,000,000 tons or about a half of all the world resources of this ore.

In the future 80 to 85 per cent of all the iron ore produced will be mined in the following four iron-ore areas of the country: the Krivoy-Rog (the Ukraine) the Kursk Magnetic Anomaly (Central European part of the country) the Kustanai (Kazakhstan) areas and in Siberia. Big ore mining enterprises with output capacities of 33,000,000 tons of iron ore a year each will be built at these deposits.

Open-pit ore mining, more efficient economically, will go up from 56 per cent in 1961 to 80 per cent in 1980. Due to the large-scale application of open-pit ore mining, measures are being taken to devise and build new types of equipment—powerful rotary excavators and conveying and handling facilities. The production

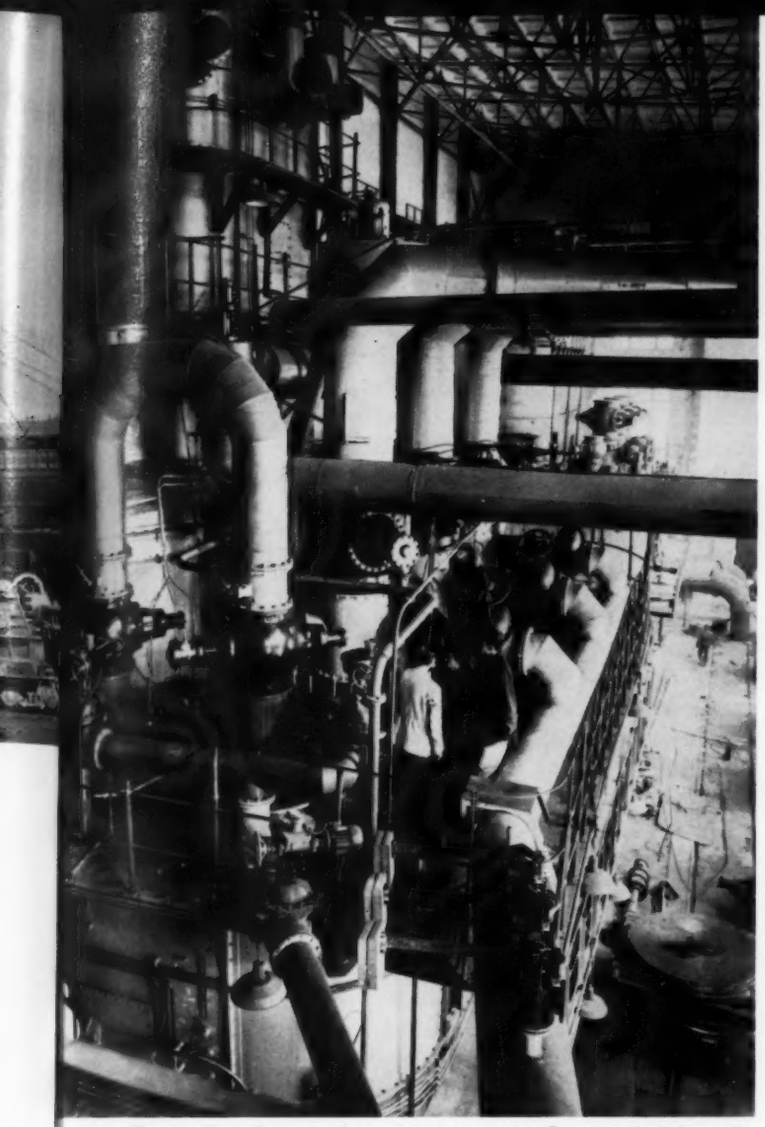


Figure 7 — Oxygen department at the Zaporozhstal works in the Ukrainian SSR.

of giant rotary excavators with handling capacities of 18,000, 36,000 and 110,000 cu ft per hr has already been started.

About 80 per cent of the ore mined will be used in blast furnaces after being dressed. The iron content in the concentrate will be brought up to 68 per cent.

An iron and steel plant of the future may appear as follows: iron-ore concentrates with a high iron content are charged into combined plant for the direct reduction of iron and production of liquid steel. From here the steel goes through continuous teeming, rolling and heat treatment. All this proceeds continuously on automatic equipment. Of course, that is a picture of the distant future, but Soviet scientists are already concentrating their efforts both on improving the existing technologies and on creating new technological processes based on the latest achievements of physics, chemistry, physical chemistry and mathematics.

The people are deeply confident that the 20-year plan mapped for the development of the country's economy and culture will be successfully translated into reality. They are confident that the USSR's iron and steel industry will be the world's largest as far as gross iron and steel output, is concerned.

The authors are quite aware that this artic'e does not cover fully all the questions involved in the present achievements and nearest prospects of the

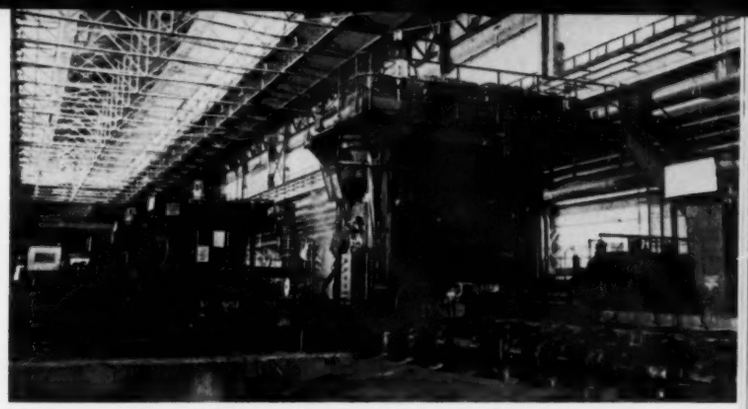


Figure 8 — The "2500" rolling mill at the Magnitogorsk Iron and Steel works is now in operation.

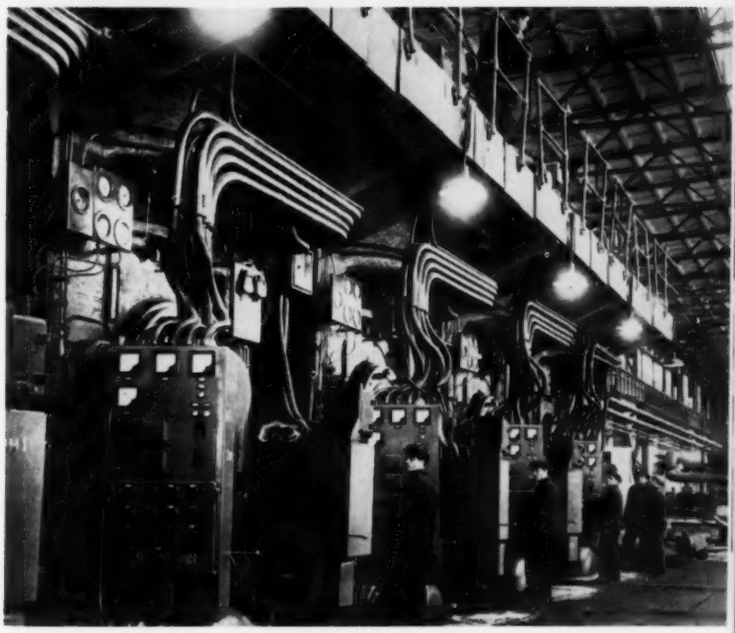


Figure 9 — Five-stand mill is used for cold metal rolling, at the Novo-Lipetsk Iron and Steel works.

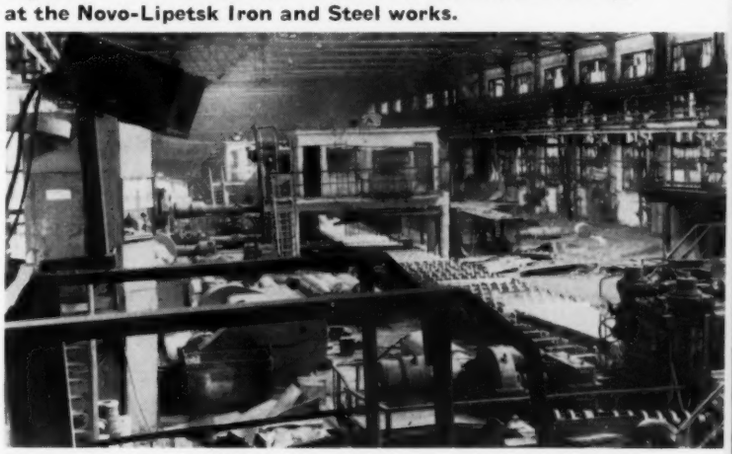


Figure 10 — At the Magnitogorsk Iron and Steel works, the "eye" of the television set (upper left-hand corner) watches where the ready rolled metal sheets leave the machine, how the machine cuts the sheets, and stamps each one, certifying that the sheets has been made from a definite grade of steel.

USSR's iron and steel industry, but they hope that readers abroad will get at least a general idea of the Soviet Union's iron and steel industry. The authors would be quite satisfied if this article contributed to some extent to bringing the metallurgists of the USSR and the U. S. closer together, to fostering mutual understanding between the Soviet and American peoples.

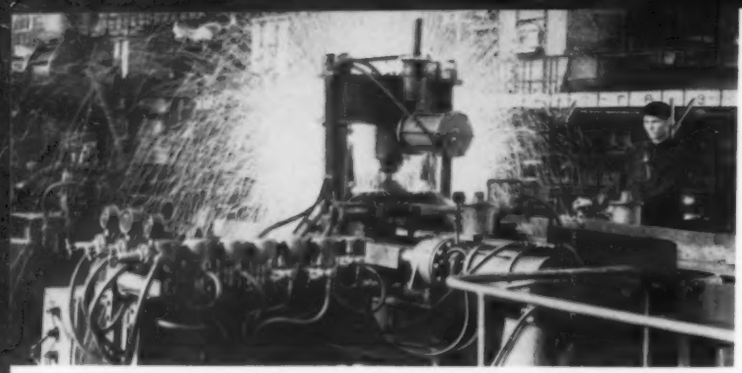


Figure 11 — This unit, set up at the pipe-rolling works in Chelyabisnk in the Urals, automatically welds strip steel.

Discussion

PRESENTED BY

I. E. MADSEN,
Association of Iron and Steel Engineers, Pittsburgh, Pa.

IVAN DENISENKO, Economist, Economic Research Institute, and ROMAN BELAN, Metallurgical Engineer, Head, Iron and Steel Industry Dept., State Planning Commission, USSR

JOHN L. YOUNG, Vice President—Engineering Technology, United States Steel Corp., Pittsburgh, Pa.

I. E. Madsen: What do the figures, "250," "2500" and "2800," mentioned in connection with the mills refer to?

Ivan Denisenko and Roman Belan: In the USSR sheet mills are designated by the length of the mill's working roll barrel, while the section mills by the diameter of its working rolls in millimeters. On one of the "2800" mills there are six stands with 1700-mm barrel length stationed behind two stands with the length of working roll barrels of 2800 mm. It is sometimes referred to as the "2800/1700."

The "2500" is a continuous mill with working roll barrel length of 2500 mm for all stands.

In the article it was said that the "2500" mill was nearing completion. At present it is already in operation. The "250" mill is a section wire mill with a 250-mm working roll diameter in the finishing stand.

I. E. Madsen: In one place, the new "2500" mill finish thickness is given as 12 mm (0.47 in.) while in another it is 6 mm (0.23 in.). Is this only an apparent discrepancy with the inference that only material up to 6 mm (0.23 in.) is cut into sheet?

Ivan Denisenko and Roman Belan: Your supposition is quite right. Strips up to 6 mm (0.23 in.) thick are cut by shears: strips with a thickness of 6 to 12 mm (0.23 to 0.47 in.) are cut by special cutting machines.

I. E. Madsen: Could you give a little more description of the evaporative cooling on open hearth and blast furnaces?

Ivan Denisenko and Roman Belan: In addition to all said to this effect in the article it may be mentioned that the essence of evaporative cooling is making use of the so-called latent heat of vapor formation to lead off heat from the furnace parts being cooled by substituting vapor-water mixture for water. Vapor formation proceeds with the input of heat and the vapor-water mixture takes it away from the parts being cooled. The steam formed, at 60-psi pressure, is chiefly employed for heating purposes. Since today's large open hearth furnaces are fitted with waste-heat boilers with a steam pressure of 265 to 660 psi, the steam pressure formed during evaporative cooling is boosted to the same values by means of forced circulation.

I. E. Madsen: We are a little confused on the description of the rolling mill used in producing extra-thin-walled pipe. Is this a stretch-reducing operation or some other procedure? Also, a figure of 18 microns is given as a minimum wall thickness for pipe. Is this figure correct?

Ivan Denisenko and Roman Belan: The decrease of pipe wall and diameter in a roller cage takes place due to the deformation of metal of the pipe billet rolled in round caliber rolls on cylindrical mounting, with a small reduction.

The minimum pipe wall thickness of 18 microns, as mentioned in our article, applies to pipes produced on a roller cage in laboratory conditions. Mass production of pipe with such wall thickness has not yet been established.

I. E. Madsen: What is the composition of the high-aluminiferous brick?

Ivan Denisenko and Roman Belan: The high-aluminiferous brick has a high content of aluminum oxide (Al_2O_3). Depending on its application high-aluminiferous brick contains 45 to 55 and more per cent of Al_2O_3, while the content of Al_2O_3-Fe_2O_3 may be as high as 80 per cent and more. The refractory properties of such brick come to 3200 to 3400 F and higher. It stands great loads under high temperature.

The high-aluminiferous brick employed for blast furnace hearth blocks contains Al_2O_3 greater than 45 per cent, Fe_2O_3 less than 1.5 per cent; has a refractoriness not under 3200 F, and the temperature at which deformation starts under a load of 57 psi is not lower than 2500 F.

John L. Young: Can the authors give further details and description of the cold rolling of pipe by roller planetary mill?

Ivan Denisenko and Roman Belan: The planetary mill for cold rolling of pipe is still in the stage of laboratory development, so both the design of the mill and the pipe rolling processes involved have not been fully developed yet.

John L. Young: Can you give the relative cost of natural gas to the other costs, since the cost comparisons are necessary to determine whether the use of natural gas is expedient?

Ivan Denisenko and Roman Belan: It is difficult for us to give a detailed answer to this question, since we do not know the revelant data for the U. S. on the production and transportation of natural gas and coke for which natural gas is substituted. Under the conditions of the USSR the use of natural gas is quite profitable. Natural gas used in blast furnaces combined with blast heated to 2200 F and enriched by 30 to 35 per cent of oxygen yields a 30 to 35 per cent saving of coke and increases the efficiency of blast furnaces by 15 to 20 per cent. The production cost of cast iron is cut down by 10 to 15 per cent. When all the Soviet Union's blast furnaces are put to work on natural gas and oxygen, as planned for 1965, the saving in capital input involved will exceed 150,000,000rubles.

Use of natural gas in open hearth furnaces under our conditions is also quite effective economically. ▲

Coke and By-Products In 1960

by G. M. GAUDIO and I. E. MADSEN

. . . . data and material in this report are based on information or quoted from Mineral Market Reports M.M.S. No. 3255 dated July, 1961 and M.M.S. No. 3298 dated September 5, 1961 . . . .

PRODUCTION of oven and beehive coke in the U. S. in 1960 increased two per cent over the 1959 total but was 19 per cent below the average output of the reference period, 1947 to 1949, according to the Bureau of Mines, U. S. Dept. of the Interior. The slight increase in coke production was due to a gain in oven-coke output as beehive production dropped six per cent. Production of oven coke in the first quarter was high, averaging 6,100,000 tons per month but dropped steadily in the following quarters, falling to 5,200,000 tons in the second, 3,800,000 tons in the third and 3,600,000 tons in the last quarter. Beehive coke followed the production trend of oven coke with the highest output in the first quarter and dropping in the succeeding quarters. The total output of beehive coke in 1960 amounted to only two per cent of the total oven and beehive-coke production and was only about one fifth the average output of the 1947 to 1949 period.

The supply of coke in 1960 was more than adequate to meet demand and producers' stocks increased one per cent or 55,652 tons. Shipments to blast furnace plants and to other industrial plants increased slightly, whereas shipments for foundries, producer and water-gas manufacture, residential heating and exports declined. The largest decrease, among the coke-consuming groups for which statistics are collected, was in shipments to gas plants which dropped 52 per cent from 1959. Gas manufacture ranked as the third largest coke market in the 1940's but since then has declined sharply and in 1960 was no longer a major use. Another market for coke that has decreased continuously in the past two decades was in the residential or space-heating field. Shipments for this purpose amounted to less than one per cent of the total coke disposal in 1960 compared with 14 per cent in 1940. Shipments to blast furnace plants increased five per cent over 1959 and amounted to 91 per cent of the total coke used and/or sold by producers in 1960. The most significant development in the use of coke in 1960 was the acceleration in the decline in coke rates in blast furnaces which dropped four per cent or 69.8 lb per ton of pig iron and ferroalloys. Coke rates have declined steadily for the past decade because of improvements in the chemical and physical properties of coke, richer burdens and advancements in blast furnace technology. Gaseous-fuel injection, a blast furnace technique, was successfully used by a few iron and steel companies and may lower coke rates substantially below the 1960 level.

Coke used for miscellaneous industrial purposes, which the Bureau of Mines classifies as "other industrial," increased seven per cent. Coke reported in this category is used for a wide variety of purposes such as chemical processing, nonferrous smelting, lime burning (for soda-ash and beet-sugar manufacture) electrometallurgical furnaces (reduction of ferroalloys) and many others. The largest single use in this group is in the manufacture of calcium carbide for which it was estimated more than 700,000 tons were used.

Production of coke screenings or breeze declined slightly from the 1959 output. For many years this material was used primarily for generating steam at or near producing plants. However, in the past decade the consumption pattern for breeze has changed markedly, mainly because of the rapid increase in its use for agglomerating iron ore and smelting phosphate rock. In 1960, only 31 per cent of the coke-breeze production was used by producers for generating steam, 36 per cent for agglomerating iron ore at blast furnace plants and 39 per cent was sold or used for miscellaneous industrial applications, including production of elemental phosphorus. The increased demand for breeze stimulated prices, and the average value per ton of breeze sold was 118 per cent higher than in the 1947 to 1949 period. Most of the breeze used in phosphate furnaces in the western states, Tennessee and Florida was shipped by rail over great distances, adding considerably to the delivered price of breeze at these installations.

Coking-coal costs are extremely important to coke-

TABLE I

Statistical Trends of the Coke Industry in the United States

	1937	1957	1958	1959	1960
Production:					
Oven coke, net tons	49,210,748	73,860,692	53,005,730	54,789,276	56,219,108
Beehive coke, net tons	3,164,721	2,090,029	598,372	1,074,296	1,009,610
Total, net tons	52,375,469	75,950,721	53,604,102	55,863,572	57,228,718
Per cent oven coke	94.0	97.2	98.9	98.1	98.3
Stocks of coke, end of year, net tons	2,595,287	3,147,776	3,823,364	4,682,436	4,738,088
Exports, all coke, net tons	526,683	822,244	392,817	460,222	282,369
Imports, all coke, net tons	286,364	117,951	121,517	123,255	125,160
Indicated consumption, all coke, net tons:	51,271,929	74,432,093	52,658,214	54,667,533	56,945,210
Furnace coke, net tons	36,751,969	68,769,998	47,597,825	49,377,383	51,837,872
Foundry coke, net tons	2,038,822	2,588,860	2,145,018	2,621,176	2,428,685
Other industrial coke (including producer and water gas) net tons	4,597,894	3,116,438	2,591,353	2,234,828	2,482,917
Domestic coke, net tons	8,107,518	662,625	603,876	470,367	397,378
Carbonizing equipment:					
By-product ovens in existence, end of year	12,718	15,897	16,244	15,993	15,323
Beehive ovens in existence, end of year	12,194	9,519	8,682	7,448	7,583
By-product ovens under construction, end of year	259	611	149		
Cost of coal charged, oven-coke plants average per ton	$3.74	$9.91	$9.89	$9.88	$9.89
Prices of coke:					
Average realization on oven coke sold (merchant sales)					
Furnace coke	$4.34	$16.08	$15.37	$15.92	$15.71
Foundry coke	$8.47	$28.77	$28.93	$30.33	$30.25
Other industrial coke (including water gas)	$6.08	$15.74	$16.10	$15.84	$15.76
Domestic coke	$6.53	$17.12	$17.14	$17.22	$17.24
Yield of by-products per ton of coal charged:					
Tar, gal	8.67	8.32	8.83	8.41	8.62
Ammonium sulphate or equivalent, lb	21.84	19.56	19.86	18.70	18.80
Crude light oil, gal	2.86	2.94	2.95	2.81	2.99
Surplus gas sold or used (does not include gas used in heating oven) M cu ft	6.66	6.55	6.62	6.60	6.52
Average gross receipts for by-products, per ton of coke produced:					
Crude tar sold and used (exclusive of amount used by producers for own use in refining and topping and exclusive of tar derivatives)	$0.502	$1.070	$1.11	$1.09	$1.20
Ammonia and its compounds	$0.326	$0.409	$0.440	$0.47	$0.38
Crude light oil and its derivatives (including naphthalene)	$0.435	$1.064	$0.96	$0.88	$1.04
Surplus gas sold or used	$1.483	$2.23	$2.33	$2.26	$2.22
Total coal-chemical materials (including breeze)	$2.974	$5.87	$6.11	$5.73	$5.94

plant operators because coal represents a major part of the total manufacturing costs of coke. The average value per ton of coal delivered to both oven and beehive-coke plants was $9.82, an increase of 2¢ per ton. Increased productivity in the bituminous coal industry, through mechanization of mines, held coal prices down in spite of increases in miners' wages and freight rates. According to price indexes published by the Bureau of Labor Statistics, the index for metallurgical-quality high-volatile coal, f.o.b. mines, decreased in 1960. The Bureau of Labor Statistics, using 1958 as a base year for measuring coal-price trends, showed that the index for metallurgical-quality high-volatile coal, f.o.b. mines, dropped from 98 in January, 1960, to 97.4 in December; while low and medium-volatile metallurgical coal remained at 96 throughout the year. This same source showed that the f.o.b. mine price of high-volatile coal dropped from $6.379 per ton to $6.343; while low-volatile coal stayed at $6.73 per ton. However, increases in freight rates brought up the delivered price of coal to oven-coke plants to the same figure as 1958.

For the first time in several years, the number of beehive ovens at the end of the year was larger than at the beginning. The gain in number of beehive ovens was due to the construction of two new beehive-coke plants, one in Pennsylvania and one in Kentucky, which raised the number of beehive ovens from 7448 to 7583 and increased annual beehive-coke capacity by 247,100 tons to 4,615,900 tons.

Output of the basic coal-chemical materials in 1960 increased over the 1959 figures primarily because more coal was carbonized in slot-type coke ovens and also because of the increase in yields. When compared with 1959 production, crude light-oil output increased ten per cent; crude tar, five per cent; ammonia (sulphate equivalent of all forms) three per cent; and coke-oven gas, four per cent. The increase in crude light-oil supply made more available for refining at coke plants and resulted in gains in production of all of the light-oil derivatives. Benzene, the most important derivative, was in tight supply throughout the year which caused the average price of coke-oven benzene to increase from an average of 28.9¢ per gal to 32.1¢. Probably the most important development in 1960 relating to the production of aromatic chemicals (benzene, toluene, xylene, naphthalene, etc.) was the tremendous expansion program started in the petroleum industry. The impetus for starting this expansion program was the anticipated increase in benzene requirements, which will be much higher than can be obtained from coal carbonization and imports.

Pitch-of-tar sales by coke-plant operators continued to increase in 1960 rising 112 per cent over 1959 and value of sales exceeded $5,000,000. However,

TABLE II

Salient Statistics of the Coke Industry in the United States in 1960

	By-product	Beehive ovens	Total
Coke produced:			
At merchant plants, net tons	6,364,540	(1)	(1)
At furnace plants, net tons	49,854,568	(1)	(1)
Total, net tons	56,219,108	1,009,610	57,228,718
Screenings or breeze produced, net tons	3,705,446	37,669	3,743,115
Coal charged into ovens, net tons	79,743,529	1,641,410	81,384,939
Average value of coal per ton	$9.89	$6.11	$9.82
Average yield in per cent of total coal charged:			
Coke	70.50	61.51	70.32
Breeze (at plants actually recovering)	4.65	4.82	4.65
Ovens:			
In existence January 1	15,993	7,448	.....
In existence December 31	15,323	7,583	.....
Annual coke capacity December 31, net tons	78,876,900	4,615,900	83,492,800
Coke used by producer:			
In blast furnaces, net tons	47,729,475	31,395	47,760,870
In foundries, net tons	199,251	...	199,251
To make producer and water gas, net tons	76,343	...	76,343
For other purposes, net tons	597,354	...	597,354
Coke sold (commercial sales):			
For blast furnace use, net tons	3,485,549	591,453	4,077,002
For foundry use, net tons	2,222,542	6,892	2,229,434
For manufacture of water gas, net tons	32,820	...	32,820
For other industrial use, net tons	1,391,830	384,570	1,776,400
For domestic use, net tons	396,927	451	397,378
Disposal of screenings or breeze			
Used by producers:			
For steam, net tons	1,142,730	...	1,142,730
For sintering iron ore, net tons	1,343,515	...	1,343,515
For other purposes, net tons	479,740	...	479,740
Sold, net tons	936,241	35,999	972,240
Average receipts per ton sold (merchant sales):			
Furnace coke	$15.82	$15.02	$15.71
Foundry coke	$30.29	$15.76	$30.25
Water-gas coke	$18.18	...	$18.18
Other industrial coke	$16.23	$13.79	$15.70
Domestic coke	$17.25	$14.39	$17.24
Screenings or breeze	$8.50	$2.37	$8.27
By-products produced:			
Tar, gal	687,559,703	...	687,559,703
Ammonium sulphate or equivalent, lb (3)	1,470,882,000	...	1,470,882,000
Gas, M cu ft	835,292,413	...	835,292,413
Burned in coking process, per cent	35.89	...	35.89
Surplus sold or used, per cent	62.35	...	62.35
Wasted, per cent	1.76	...	1.76
Crude light oil, gal	234,500,663	...	234,500,663
Yield of by-products per ton of coal:			
Tar, gal	8.62	...	8.62
Ammonium sulphate or equivalent, lb (3)	18.80	...	18.80
Gas, M cu ft	10.47	...	10.47
Crude light oil, gal	2.99	...	2.99
Coal used per ton of coke, tons	1.42	1.63	1.42
Value of coke at ovens	$1,033,167,857	$14,752,563	$1,047,920,420
Value of screenings or breeze	$27,436,205	$87,486	$27,523,691
Value of by-products sold:			
Tar sold and used by producer	$100,242,636	...	$100,242,636
Ammonia (sulphate and liquor) (3)	$21,844,671	...	$21,844,671
Gas (surplus)	$125,735,415	...	$125,735,415
Crude light oil and derivatives (2)	$58,922,666	...	$58,922,666
Total value of coke and breeze produced and coal-chemical materials sold and tar used by producer	$1,367,349,450	$14,840,049	$1,382,189,499

(1) Not separately recorded. (2) Includes intermediate light oil. (3) Includes diammonium phosphate, ammonium thiocyanate and monoammonium phosphate.

roughly 80 per cent of the coal-tar-pitch production at coke plants was used as fuel in integrated open hearth furnaces. As the economic value of this pitch is determined largely by its fuel value, several of the major pitch-producing companies were considering producing and marketing special pitch products to enhance its economic importance to the producing companies.

The total value of the coal carbonized in 1960 amounted to $798,824,194. The value of all coal-chemical materials used and/or sold and coke and breeze produced was $1,382,189,499 or 73 per cent more than the value of the coal. The value of coke and breeze produced amounted to 78 per cent of the value of all products. Coal-chemical materials, including surplus gas, comprised the balance. Table I contains salient statistics of the coke industry and Table II is a statistical summary of the coke industry in 1960.

PRODUCTION OF COKE

In 1960 by-product coke production averaged 154,000 tons daily compared with 150,000 tons per day in 1959. Beehive-coke production averaged 2760 tons per day, a slight drop from the 2950 tons per day in

TABLE III

Summary of Oven-Coke Operations in the United States in 1960, by States

State	In existence Dec. 31 ①		Coal carbonized, net tons	Yield of coke from coal, per cent	Coke produced, net tons	Value of coke at ovens	
	Plants	Ovens				Total	Per ton
Alabama	7	1,451	6,718,458	72.89	4,897,286	$ 99,558,578	$20.33
California, Colorado and Utah	4	829	4,504,555	63.05	2,840,131	71,450,903	25.18
Connecticut, Maryland, Massachusetts, New Jersey and New York	6	1,905	9,914,668	71.32	7,071,167	119,710,542	16.93
Illinois	6	507	2,874,399	68.57	1,971,107	37,108,601	18.83
Indiana	5	2,191	11,155,151	71.93	8,024,273	156,066,508	19.45
Kentucky, Missouri, Tennessee and Texas	5	420	2,749,175	71.76	1,972,816	37,266,880	18.89
Michigan	4	769	4,439,025	73.86	3,278,739	59,657,982	18.20
Minnesota and Wisconsin	4	400	1,188,272	70.36	836,072	19,734,512	23.60
Ohio	14	2,368	11,738,938	71.75	8,423,246	142,066,358	16.87
Pennsylvania	14	3,792	20,422,815	69.27	14,146,269	242,467,506	17.14
West Virginia	4	691	4,038,073	68.30	2,758,002	48,079,487	17.43
Total 1960	73	15,323	79,743,529	70.50	56,219,108	$1,033,167,857	$18.38
At merchant plants	19	2,025	8,900,616	71.51	6,364,540	134,553,708	21.14
At furnace plants	54	13,298	70,842,913	70.37	49,854,568	898,614,149	18.02
Total 1959	74	15,993	77,722,907	70.49	54,789,276	$ 976,343,886	$17.82

① Excludes plants retired permanently during year.

1959. Once again Pennsylvania was the most important state in the production of by-product coke with a total of 14,146,269 tons, 20.2 per cent of the U. S. total. Ohio, Indiana and Alabama with tonnages of 8,423,246; 8,024,273; and 4,897,286 respectively, followed Pennsylvania in coke production. Michigan and West Virginia each produced about 3,000,000 tons. The states of Connecticut, Maryland, Massachusetts, New Jersey and New York had a combined total coke production of 7,071,167 tons. Pennsylvania also was the leading producer of beehive coke in 1960 with a production of 684,250 tons, slightly less than the 713,150 tons produced in 1959. The three other states producing beehive coke, Kentucky, Virginia and West Virginia, produced a total of 325,360 tons. Thus total beehive production was 1,009,610 tons, 67.75 per cent of which was produced in Pennsylvania.

Moreover, Pennsylvania was the leading producer of all types of coke with 14,820,519 tons or 20.6 per cent of the total U. S. production, which is a large percentage reduction from the 1959 figure of 25.9 per cent even though Pennsylvania coke production rose slightly from the 14,468,996 tons of 1959.

World production figures reveal that the U. S. lags behind the USSR in coke production: 61,100,000 tons to 57,229,000 tons. This is a trend that started in 1958 when U. S. production dropped to 53,604,000 tons from the 75,951,000 tons produced in 1957. The next ranking world producers are West Germany (including the Saar) with 49,222,000 tons; China with 27,600,000 tons; United Kingdom with 20,966,000 tons; France with 14,999,000 tons; Poland with 12,437,000 tons and Japan with 9,424,000 tons. Total world production in 1960 was 306,720,000 tons compared with 289,689,000 tons in 1959 and 281,308,000 tons in 1958.

NUMBER AND CAPACITY OF OVENS

A total of 15,323 by-product ovens were in existence as of December 31, 1960 which compared with a total of 15,993 by-product ovens in existence on December 31, 1959, representing a decrease of 670 ovens. Pennsylvania led in the number of by-product ovens with 3792 ovens, followed by Ohio with 2368 ovens, Indiana with 2191 ovens and Alabama with 1451 ovens. Pennsylvania, Ohio and Alabama had fewer ovens than in 1959, while the Indiana total was the same. Total capacity of the by-product ovens in existence at the end of 1960 was 78,876,900 tons, compared with 81,447,700 tons capacity at the end of 1959.

The number of beehive coke ovens in existence as of December 31, 1960, totaled 7583, which is an increase of 135 ovens from the 7448 in existence on December 31, 1959. Of the total 7583 ovens, 6208 were located in Pennsylvania while the remaining 1375 ovens were located in the grouped states of Kentucky, Virginia and West Virginia, both figures representing increases

TABLE IV

Summary of Beehive-Coke Operations in the United States in 1960, by States

State	In existence Dec. 31 ①		Coal carbonized, net tons	Yield of coke from coal, per cent	Coke produced, net tons	Value of coke at ovens	
	Plants	Ovens				Total	Per ton
Pennsylvania	33	6,208	1,088,515	62.86	684,250	$ 9,704,321	$14.18
Kentucky, Virginia and West Virginia	10	1,375	552,895	58.85	325,360	5,048,242	15.52
Total 1960	43	7,583	1,641,410	61.51	1,009,610	$14,752,563	$14.61
Total 1959	45	7,448	1,827,474	58.78	1,074,296	$15,740,926	$14.65

① Excludes plants retired permanently during year.

from 1959. The total capacity of the beehive ovens in existence on December 31, 1960, was 4,615,900 tons compared with 4,368,800 tons on December 31, 1959. Thus the total annual capacity of all U. S. coke ovens was 83,492,800 tons, as of December 31, 1960.

COAL CHARGED INTO OVENS

Total coal carbonized in 1960 amounted to 80,832,044 tons, compared with 79,550,381 tons in 1959. Of the total 79,743,529 tons, with a value of $788,798,803, charged into by-product ovens, 79,373,267 tons were bituminous coal with a value of $784,980,277 and 370,262 tons were anthracite coal with a value of $3,818,526. Average value per ton of bituminous was $9.89, average value per ton of anthracite was $10.31 and the over-all average value per ton of coal was $9.89, compared with $9.88 in 1959.

There was a total of 1,641,410 tons of coal carbonized in beehive ovens in 1960, all of which was bituminous with a total value of $10,025,391 and an average value per ton of $6.11, compared with a value of $6.10 per ton in 1959.

The total over-all average value of coal charged into coke ovens in 1960 was $9.82 per ton compared to $9.80 per ton in 1959.

For each ton of coke produced in the by-product ovens in 1960, 1.42 tons of coal was charged into them, exactly the same as the 1.42 tons of coal per ton of coke required in 1959. Beehive coke ovens required 1.63 tons of coal to produce a ton of coke in 1960, which was less than the 1.70 tons required in 1959. Thus the cost of beehive coke dropped by about five per cent in 1960 while by-product coke costs increased slightly, compared with 1959.

The leading states with regard to the mining of coal for carbonization in by-product ovens in 1960 were: West Virginia, Pennsylvania, Kentucky, Alabama and Virginia with respective production figures of 31,272,536; 22,834,884; 10,200,993; 6,285,108; and 3,525,695 tons, for a total of 74,119,216 tons or 93.8 per cent of the 80,080,167 tons delivered to by-product plants. Total coal delivered to by-product plants for conversion in 1959 amounted to 77,411,926 tons.

COKE USAGE AND DISTRIBUTION

The apparent coke consumption in the U. S. in 1960 was 56,945,210 tons, an increase of 4.1 per cent from the 54,667,533 tons consumed in 1959. The difference between production and consumption amounted to 283,508 tons, 125,610 tons were imported, 353,016 tons were exported and 55,652 tons went toward increasing producers' stocks, which totaled 4,738,088 tons as of December 31, 1960.

Once again the blast furnaces consumed the largest percentage of coke, 51,810,501 tons plus 27,371 tons which were exported for blast furnace use. Blast furnace consumption totaled 90.6 per cent of U. S. production, which is both a percentage and a total increase from 1959 when 49,417,214 tons, 88.8 per cent of total production, were used by blast furnaces.

The coke needed to make a net ton of pig iron and ferroalloys was 1516.4 lb compared with 1582.2 lb in 1959, a drop of about 70 lb which reflects the further use of agglomerates and fuel injection, both gaseous and solid, in the blast furnace. Actual coking-coal consumption per net ton of pig iron and ferroalloys was 2157 lb compared to the 2259 lb required in 1959.

Foundries consumed 2,428,685 tons of coke including 78,107 tons which were exported, amounting to 4.1 per cent of the total coke usage in 1960, compared with 2,689,848 tons and 4.86 per cent in 1959.

Continuing the trend shown in past years, coke shipped to producer and water-gas plants dropped to 109,163 tons in 1960 from the 227,666 tons shipped in 1959. The total shipped to other industrial plants in 1960 was 2,373,754 tons, including 174,403 tons which were exported, while the 1959 figure was 2,214,532 tons. Residential heating shipments in 1960 totaled 394,890 tons, of which 2488 tons were exported, compared to 473,488 tons shipped in 1959.

The majority of the coke produced is used in steelmaking operations, and a large amount of it is produced by plants located close to the consuming operation to reduce transportation costs. Pennsylvania, which was the largest producer, was also the largest consumer of coke in 1960, with a total usage of 14,573,273 tons, compared with 13,333,761 tons in 1959. Next in line was Ohio with a total usage of 9,762,797 tons, compared with 9,951,062 tons in 1959. Trailing were: Indiana, 5,940,454 tons; Illinois, 4,330,580 tons; Michigan, 4,077,102 tons; Alabama, 3,766,555 tons; New York, 3,517,694 tons; and Maryland, 3,040,609 tons.

STOCKS OF COKE AND COKING COAL

Coke stocks increased only slightly during 1960, by 55,652 tons, to a total of 4,738,088 tons at the beginning of 1961. Producers stocks of coking quality coal were reduced by 336,638 tons during 1960. Coke-breeze stocks were decreased by 195,110 tons in 1960.

GROSS VALUE AND YIELDS OF BY-PRODUCTS

The total gross value of all coal-chemical materials produced in the U. S. in 1960 totaled $306,745,388, compared with $288,153,722 in 1959. Since some of the by-products were used by the producers, the total value of coal-chemicals sold was $274,291,638. The gross value of the by-products was about 24.3 per cent of the $1,382,189,499 which was the total value of all products, including coke breeze. Total value of the coke purchased, at the ovens, was $1,033,167,857 while the value of the coke breeze was $27,436,205. An average of $24.32 per ton of by-product coke was realized from the coke, coke breeze and coal-chemical materials produced in the U. S. in 1960, compared with $23.65 per ton in 1959. This figure includes $18.38 for the coke, 48.3¢ for the coke breeze and $5.46 for the coal-chemical materials. Coal cost per ton of by-product coke was $14.01 in 1960, compared with $14.02 in 1959. The average value of beehive coke was $14.61 per ton, while the coal cost per ton was $9.95 compared with $10.38 per ton in 1959.

The dollar return for primary by-products in 1960 was slightly above the 1959 figure, as the physical

TABLE V

Coal-Chemical Materials, Exclusive of Breeze, Produced at Coke-Oven Installations in the United States in 1960 (1)

Product	Produced	Sold			On hand Dec. 31
		Quantity	Value		
			Total	Average	
Tar, crude, gal	687,559,703	333,253,840 (2)	$ 42,640,937	$ 0.128	25,587,405
Tar derivatives:					
Sodium phenolate or carbolate, gal	2,945,432	2,803,810	447,018	0.159	292,105
Crude chemical oil (tar acid oil) gal	27,578,681	27,325,877	5,763,027	0.211	219,734
Pitch-of-tar: (3)					
Soft, net tons	748,921	53,608	1,263,976	23.578	21,432
Medium, net tons	57,944	46,993	1,266,376	26.948	2,964
Hard, net tons	233,667	76,981	2,628,865	34.150	4,744
Other tar derivatives (4)	...	...	13,778,687	...	...
Ammonia products:					
Sulphate, net tons (5)	631,643	594,108	$ 17,231,502	$ 29.004	136,124
Liquor (NH_3 content) net tons	14,884	9,397	635,833	67.663	734
Di- and mono-ammonium phosphate, net tons	46,067	36,523	3,977,336	108.899	14,895
Total	...	...	$ 21,844,671	...	...
Sulphate equivalent of all forms, net tons	735,441	596,624	...	...	...
NH_3 equivalent of all forms, net tons	189,598	171,974	...	...	...
Gas:					
Used under boilers, etc., M cu ft	835,292,413 (6)	66,368,699	$ 13,107,186	$ 0.197	...
Used in steel or allied plants, M cu ft		394,535,298	94,850,750	0.240	...
Distributed through city mains, M cu ft		29,777,016	11,964,585	0.402	...
Sold for industrial use, M cu ft		30,095,237	5,812,894	0.193	...
Total	835,292,413	520,776,250	$125,735,415	$ 0.241	...
Crude light oil, gal	234,500,663 (7)	21,280,379	3,845,657	0.181	3,320,402
Light oil derivatives:					
Benzene:					
Specification grades (excluding motor grade) gal	135,326,446	137,784,200	$ 44,166,604	$ 0.321	3,585,160
Motor grade, gal	769,949	774,291	141,858	0.183	20,415
Toluene (all grades) gal	30,398,543	31,566,744	6,638,373	0.210	1,750,176
Xylene (all grades) gal	8,075,608	7,853,506	2,061,013	0.262	847,063
Solvent naphtha (crude and refined) gal	4,586,363	4,578,240	1,209,360	0.264	353,179
Other light oil derivatives, gal	3,686,255	1,634,153	224,455	0.135	172,195
Total	182,843,164	184,191,134	$ 54,441,663	$ 0.296	6,728,188
Intermediate light oil, gal	3,590,177	3,713,616	635,346	0.171	116,623
Value of all coal-chemical materials sold	...	...	$274,291,638	...	...

(1) Includes products of tar distillation conducted by coke-oven operators under same corporate name.
(2) Includes 33,345,206 gal sold to affiliated companies for refining.
(3) Soft, water-softening point less than 110 F; medium, from 110 to 160 F; hard, over 160 F.
(4) Creosote oil, cresols, cresylic acid, naphthalene, phenol, pyridine, refined tar and tar paint.
(5) Includes ammonium thiocyanate.
(6) Includes gas used for heating ovens and gas wasted.
(7) 218,242,334 gal refined by coke-oven operators to make derived products shown.

yields per ton of coal coked increased. The quantity of tar per ton of coal coked rose to 8.62 gal from 8.41 gal in 1959; ammonium sulphate increased from 18.70 lb per ton of coal coked in 1959 to 18.80 lb in 1960; crude light oil increased from 2.81 to 2.99 gal per ton of coal coked; and surplus gas sold or used dropped from 660,000 cu ft in 1959 to 652,000 cu ft in 1960.

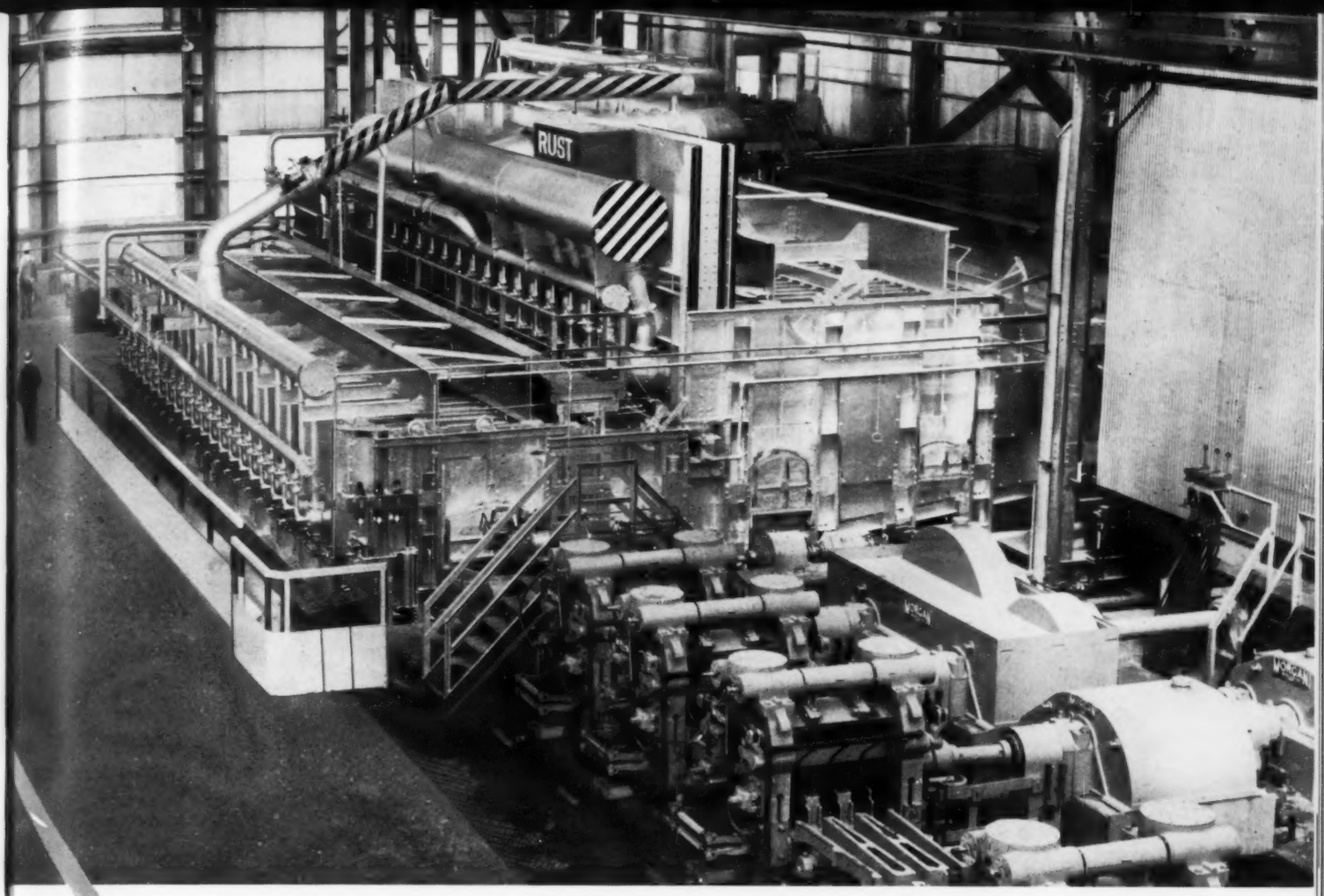
NATURAL GAS

The marketed production of natural gas in the U. S. in 1960 totaled 12,771,038,000,000 cu ft, an increase of six per cent from the 12,046,115,000,000 cu ft in 1959. Again Texas led all states in the production of natural gas with a quantity of 5,892,704,000,000 cu ft. Louisiana, Oklahoma and New Mexico followed with marketed production figures of 2,988,414,000,000; 824,266,000,000 and 798,928,000,000 cu ft respectively.

Consumption of natural gas in 1960 was 12,509,427,000,000 cu ft, also an increase of six per cent from the 1959 total of 11,819,638,000,000 cu ft. This consumption is broken down into classes, with the consumption figures and percentage changes from 1959: residential, 3,103,167,000,000 cu ft, a seven per cent increase; commercial, 1,020,222,000,000 cu ft, a five per cent increase; field use, 1,779,671,000,000 cu ft, a two per cent increase; carbon black, 197,628,000,000 cu ft, an eight per cent decrease; and industrial fuel, divided into refinery fuel, 775,154,000,000 cu ft and other industrial, 5,633,585,000,000 cu ft, for a total of 6,408,749,000,000 cu ft, a seven per cent increase. In 1960, there was a gross increase of 121,000,000,000 cu ft of gas in underground storage facilities.

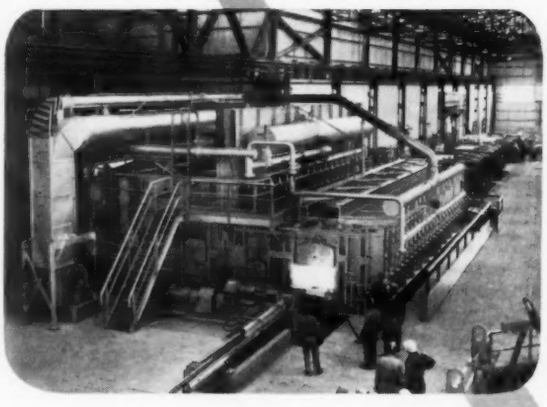
The average wellhead value of natural gas in 1960 was 14.0¢ per 1000 cu ft, an increase of 1.1¢ per 1000 cu ft from the 1959 value. Average value at the point of gas consumption was 50.1¢ per 1000 cu ft, an increase of 2.4¢ per 1000 cu ft from the 1959 value.

Natural gas imports in 1960 totaled 156,000,000,000 cu ft, which was composed of 109,000,000,000 cu ft from Canada and 47,000,000,000 cu ft from Mexico. ▲



Two-Zone Continuous
Billet Reheating Furnace

for Sheffield Division, Armco Steel Corporation



• *View from peel bar side of furnace looking toward mill.*

This double-fired, two-zone furnace was designed and constructed by Rust to reheat billets in one of the fastest 10″ rod mills in the world. The mill itself was constructed by The Rust Engineering Company for Armco Steel Corp., Sheffield Division at Kansas City, Mo. The furnace is oil-fired and has a rated capacity of 112 tons per hour.

Since 1927 Rust furnaces have been recognized throughout the world for their rugged design and dependable operation.

RUST FURNACE COMPANY

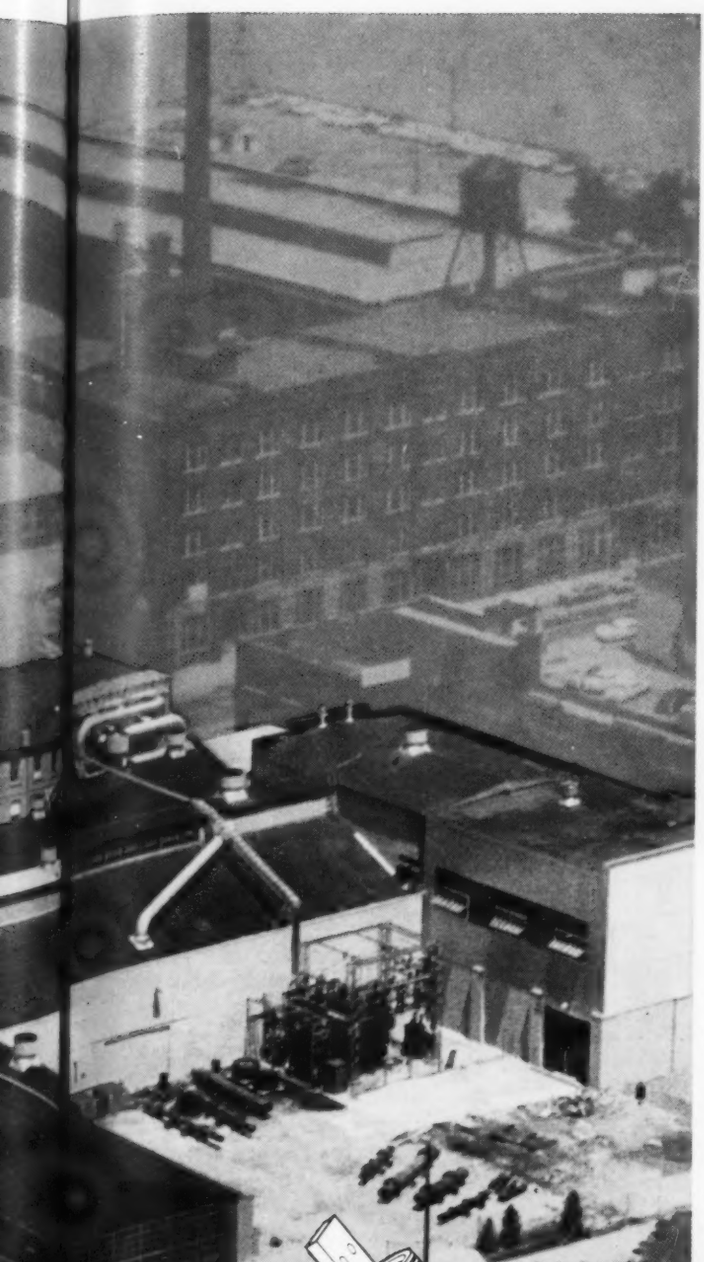
930 Fort Duquesne Boulevard, Pittsburgh 22, Pa.

First in Heating Efficiency . . . *Pioneers in Furnace Design*

F-27

Electrical Protection goes MODERN with BUSS Fuses . . .

at Sandusky Foundry & Machine Co.
Sandusky, Ohio



THIS ALL FUSE INSTALLATION PROVIDES NEEDED HIGH INTERRUPTING CAPACITY—AND SAVED AN ESTIMATED $20,000

A new electrical system was installed at the Sandusky Foundry and Machine Co., to feed a 1000 KVA annealing furnace and plant feeders and sub-feeders.

The engineers at Universal Marine Construction Co., Sandusky, Ohio who designed and installed the job, estimated the available fault current would be in the neighborhood of 75,000 amperes.

To be sure of obtaining the needed safe and dependable protection BUSS Hi-Cap and FUSETRON dual-element fuses were installed.

DEPENDABLE PROTECTION AT A $20,000 SAVING

Including the cost of fuses and switches, an estimated $20,000 was saved over what it would have cost to use mechanically operated devices with an interrupting rating of only 75,000 amperes.

This BUSS and FUSETRON fuse installation also permitted the electrical system to be co-ordinated, so outages on feeder and sub-feeder circuits can be limited to the circuit on which trouble occurs.

ELECTRICAL SYSTEM NOT DISTURBED WHEN TRANSFORMER CAPACITY WAS INCREASED

Shortly after the original installation, additional transformer capacity was added,—bringing the available fault current to approximately 150,000 amperes.

No change in the main service panels was needed, however, as the 200,000 amp. interrupting capacity of BUSS Hi-Cap fuses is still adequate to assure safe protection.

Neither was a change required in the protection of feeder circuits because FUSETRON fuses have adequate interrupting capacity to safely handle any fault that might occur on them.

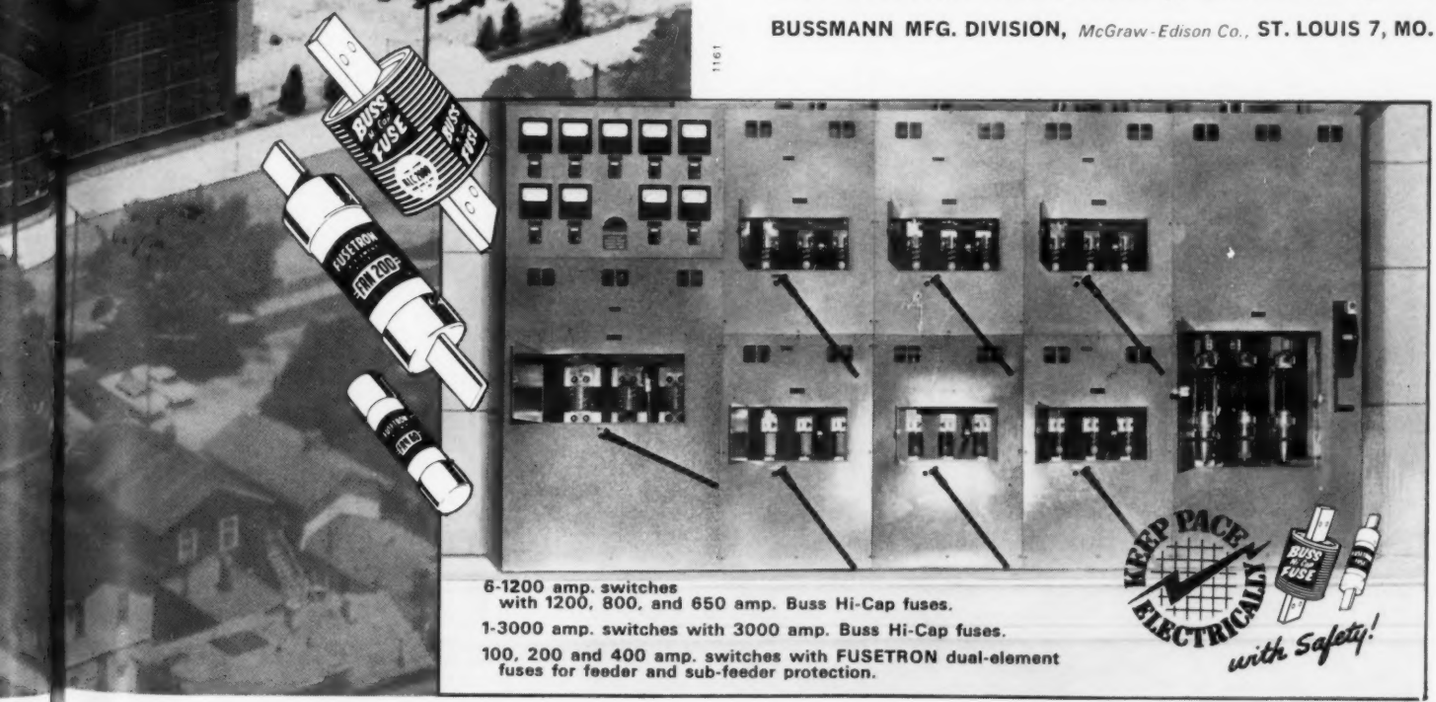
SAFE PROTECTION REMAINS SAFE

After years of inactivity, BUSS Hi-Cap and FUSETRON fuses provide the same safe, accurate protection if called upon to open as they would on the day installed. Dust, fumes, corrosion or age cannot increase the capacity of fuses or lengthen their blowing time.

For more information on how to select the proper fuse, write for the new BUSS booklet . . . *Basic Protection for Electrical Power Systems.*

BUSSMANN MFG. DIVISION, *McGraw-Edison Co.,* **ST. LOUIS 7, MO.**

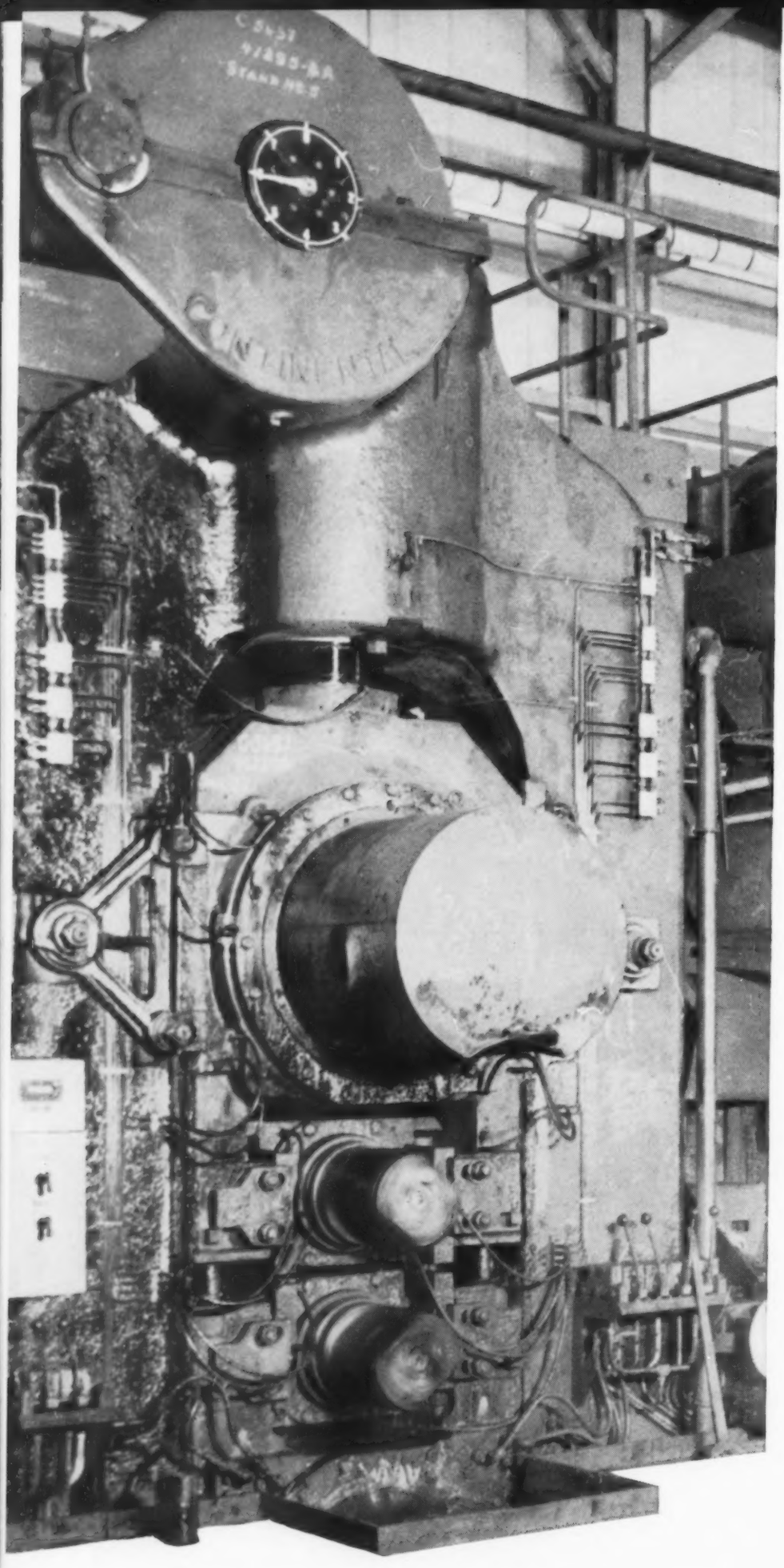
1161



6-1200 amp. switches with 1200, 800, and 650 amp. Buss Hi-Cap fuses.

1-3000 amp. switches with 3000 amp. Buss Hi-Cap fuses.

100, 200 and 400 amp. switches with FUSETRON dual-element fuses for feeder and sub-feeder protection.

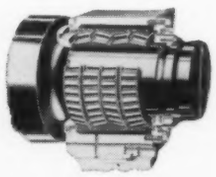


ARMCO specifies tapered roller bearings for their hot strip mill back-up rolls

Armco's 25″ & 54″ x 58″ five stand tandem hot strip mill installed in 1955 at their Butler, Pa., plant has operated without the loss of a single tapered roller back-up roll bearing. And operating expenses have been low on lubrication system maintenance and cost of lubricant. Mill downtime due to failure of bearings and lubricating system is non-existent.

Along with economy, tapered roller bearing equipped back-up rolls have provided a number of other positive benefits. They maintain positive roll location and there is minimum slippage and wear on mill rolls because of lower starting torque. Tapered roller bearings provide higher momentary overload capacity.

For the most in bearing performance and engineering service when you buy or build a mill, specify Timken® bearings. The Timken Roller Bearing Company, Canton 6, Ohio. Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits. Canadian Division: Canadian Timken, St. Thomas, Ontario.



Industry rolls on

TIMKEN

tapered roller bearings

Recently Completed Basic Oxygen Shop to Furnish Steel for New J&L Hot Strip Mill

FURNACES of the recently completed basic oxygen steelmaking shop at the Cleveland works of Jones & Laughlin Steel Corp. have gone into production. These new furnaces, first of their type in the Cleveland area, refine iron into steel through the use of a jet of high-purity oxygen. These new furnaces, more than twice the size of any of this type in the world, have produced heats of 240 tons in 59 min, while good open hearth furnaces in this country produce steel at the rate of 40 tons per hr, tap-to-tap time.

Each of the furnaces weighs 455 tons including: a 141-ton steel shell and a 314-ton lining of heat-resistant refractories. Installed by Koppers Co., Inc., and designed and built by the Pennsylvania Engineering Corp., they are 27 ft-10½ in. high and 21 ft-8½ in. in diameter at the widest point, about four ft wider than any existing furnaces. The mouths of the furnaces are seven ft in diameter.

They are held in trunnions, weighing more than 112 tons, which permit the huge furnaces to be rotated 360 deg. Twin 200-hp motors are required to tilt each furnace.

The furnaces and most auxiliary equipment are housed in new steel buildings. The principal auxiliary to the new shop is an oxygen-generating plant built by Air Products, Inc., which contains two units, capable of generating 534 tons of high-purity (99.5 per cent) oxygen per day. Approximately 1800 cu ft of oxygen are needed per ton of steel produced in the new furnaces. The oxygen plant also contains storage facilities for 815,000 cu ft of gaseous oxygen and for 18,000,000 cu ft of liquid oxygen. Moreover, the furnaces incorporate the latest equipment for smoke and dust control. They are equipped with electrostatic precipitators, which collect dust from the furnace gases through a large water-cooled hood suspended directly over each furnace. The gases are drawn into the hoods by four fans, each rated at more than 325,000 cfm. The gases are sprayed with water in a spark box to remove the heavier materials and to lower their temperature from 3000 F to less than 500 F. The precipitators also clean the waste gases from the Cleveland works open hearth furnaces.

The charging of the scrap can be accomplished, utilizing a new type of scrap charger, in less than a minute. Prior to the charging of the furnace, scrap is loaded into a

Figure 1 — One vessel is in use while the other vessel is being relined.

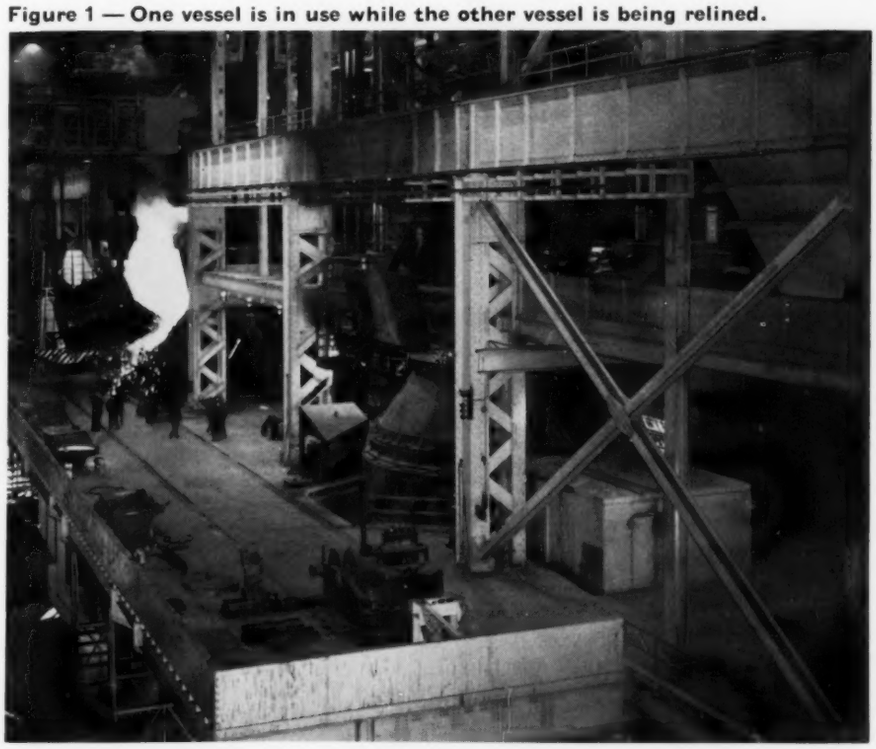


Figure 2 — Scrap charging is accomplished in a very short time, thus increasing furnace availability.

Figure 3 — The basic oxygen furnace requires a large hot-metal charge.

series of box-like containers. One of these containers in turn is loaded onto a scrap charger which, utilizing a specially-designed integral chute, can charge the furnace in a single operation. This new system, designed for J&L by Calderon Inc., is expected to reduce the conventional heat cycle by several minutes.

The slag-forming raw materials also are charged rapidly by means of conveyor belts and a chute leading from the storage bins above the furnace.

Figure 4 — The water-cooled lance is lowered into position and the oxygen flow begins.

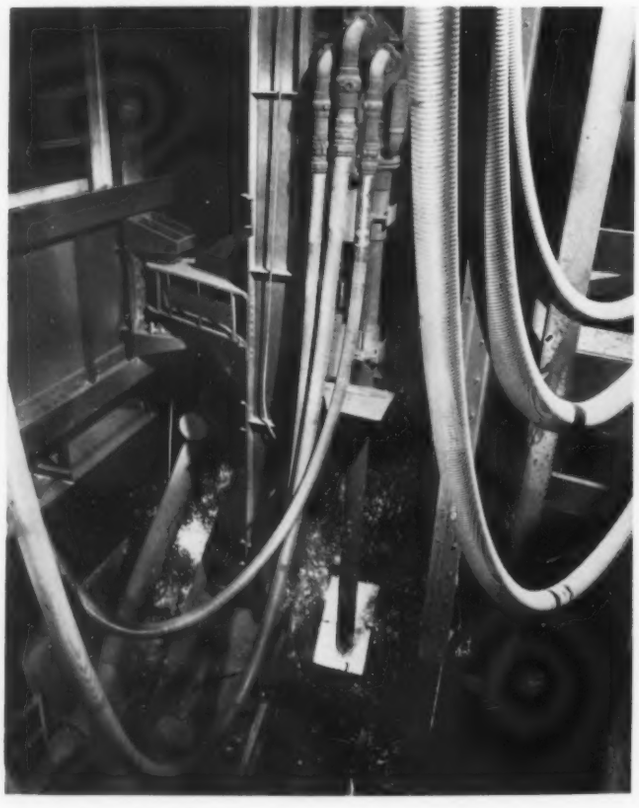
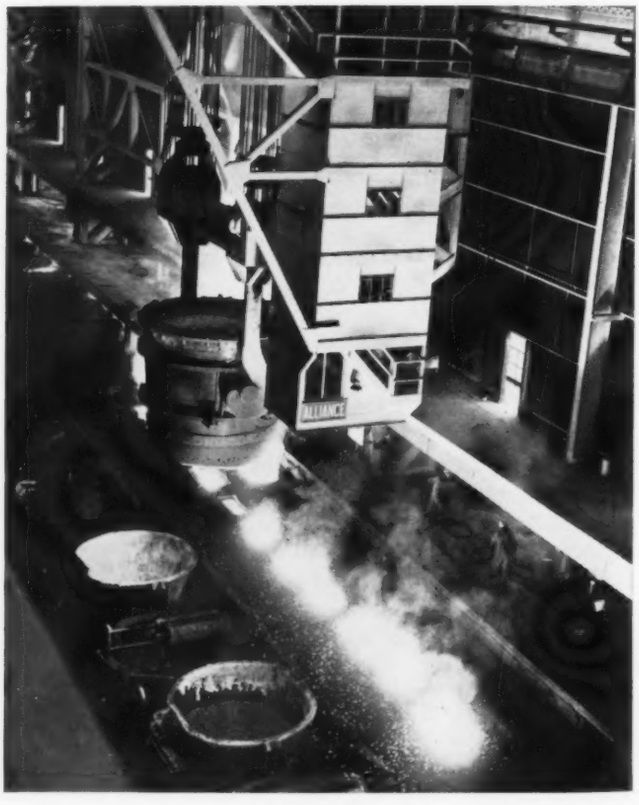


Figure 5 — The steel is teemed into 16-ton ingot molds.



Steel made in the new basic oxygen furnaces is quite low in content of nitrogen, phosphorus and sulphur. Because of the resulting characteristics, basic oxygen steel meets the specifications for production techniques in the automotive and appliance industries.

Steel from the basic oxygen furnaces at Aliquippa has been used successfully for hot and cold rolled sheets and plates, tin plate, seamless tubes, electric weld and continuous weld pipe, rods and wire, structurals, etc.

The addition of the basic oxygen process enables the Cleveland works to produce steel by three of the most modern methods. The other steelmaking facilities consist of two electric furnaces and three oxygen-lance-equipped open hearths. Eight smaller conventional open hearths, installed in 1924 when the Cleveland works was the Otis Steel Co., are to be dismantled.

J&L has spent approximately $250,000,000 since 1949 to rebuild the Cleveland plant.

In continuance of this program, bringing the total expenditure by J&L at the Cleveland works to more than $300,000,000, an 80-in. hot strip mill will be installed, and changes in existing rolling mill and steel handling facilities will be made. Construction is expected to start early in 1962, and the new facilities should be in operation late in 1963.

The decision to install a new and faster hot strip mill at Cleveland will increase J&L's ability to compete in the flat-rolled steel markets. Continued advances in design in the automotive and appliance fields demand the highest standards of quality and uniformity.

Chief advantages to be gained from the new strip mill will be uniform, high-quality surface finish on steel sheets, and larger coils of sheets demanded by customers for their production lines.

It is believed that the new mill at the Cleveland works will establish new quality standards by:

1. Improved slab conditioning and handling facilities aimed at delivering a superior quality slab to the new strip mill.

2. New reheating furnaces, as large and modern as any in the industry. These new furnaces have sufficient heating capacity to maintain optimum heating conditions for maximum speed of the new strip mill. The new slab furnaces will be able to handle larger slabs, up to 10 in. thick, 74 in. wide and 30 ft in length weighing as much as 60,000 lb.

3. Vertical and horizontal scale-breakers with extra-high-pressure hydraulic descaling sprays to completely eliminate all scale from the slab prior to its entry in the roughing stands.

4. An additional roughing stand of the continuous type which will follow the reversing roughing stand. The continuous rougher will be equipped with smooth rolls thereby providing a much smoother surface on the steel when it enters the finishing stands.

5. A greater finishing speed in the finishing rolls thereby minimizing temperature variations between the front and tail end of each coil, and permitting closer control of thickness throughout the length of the coil. The finishing stands will be more powerful than any of their type and will be powered by triple-armature 9000-hp motors on each of the six stands.

6. The mill will be equipped with the most modern temperature, thickness and width control systems to automatically insure the closest possible dimensional tolerances.

The six finishing mill stands of the new mill will turn out coils at a speed of up to 3750 fpm, more than ten per cent faster than the speed of any existing mill of its type.

Coils will be up to 74 in. wide, and in coils ultimately weighing as much as 60,000 lb.

In order to handle steel for processing after the new mill, additional facilities will be installed:

1. New coilers to handle the steel as it leaves the finishing stands of the strip mill.

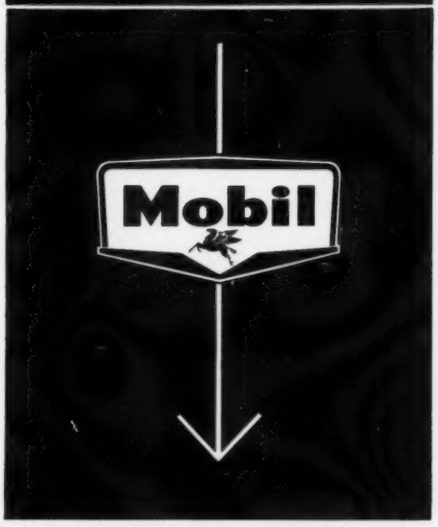
2. New coil handling facilities between the new strip mill and the cold rolling mills, which will include modification of coil handling devices at the two continuous pickling lines and at the shear lines.

Several new buildings, including a modern shipping building, will be constructed to house the new strip mill. The present hot strip mill will be deactivated when the new facilities are ready for operation. ▲

USE THE COUPON BELOW FOR MORE INFORMATION ON NEW ECONOMICAL

PYROGARD C
FIRE-RESISTANT FLUID

See ad on following pages



Mobil Oil Company, Room 2058H
A Division of Socony Mobil Oil Co., Inc.
150 East 42nd Street, New York 17, N.Y.

Gentlemen: I am interested in learning how new PYROGARD C fire-resistant fluid can aid my operation.

NAME _____
POSITION _____
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FOR IMPROVED PLANT SAFETY PLUS

NEW, ECONOMICAL

PYROGARD C

FIRE-RESISTANT FLUID

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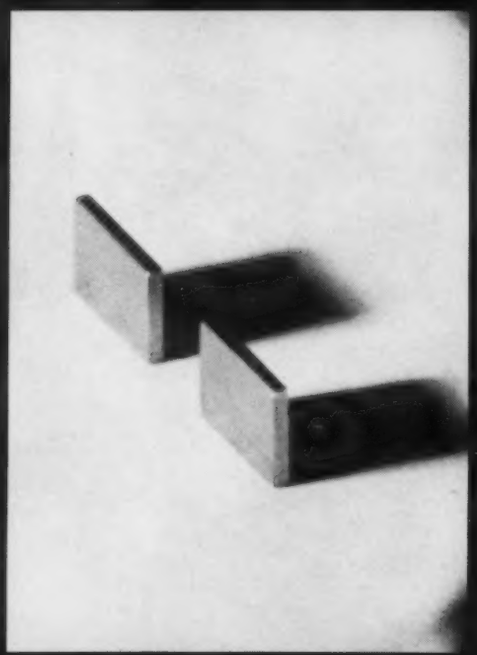
HERE'S HOW PYROGARD C CAN HELP YOU!

Ignition resistance increases mill safety—PYROGARD C helps you protect your property and personnel against fire. Ignition resistance is demonstrated here. Hydraulic oil (left) bursts into flame immediately and PYROGARD C (right) resists combustion when poured onto steel plate heated to 1000F.



Good anti-wear properties assure long pump life—PYROGARD C fire-resistant fluid is designed for most pumps and pressures encountered in mill hydraulic equipment . . . gives excellent protection against pump wear for fluids of this type. Pump vane at left is new. Vane at right has 1000 hours of service with PYROGARD C at 160F and 1000 PSI. Wear is almost undetectable.

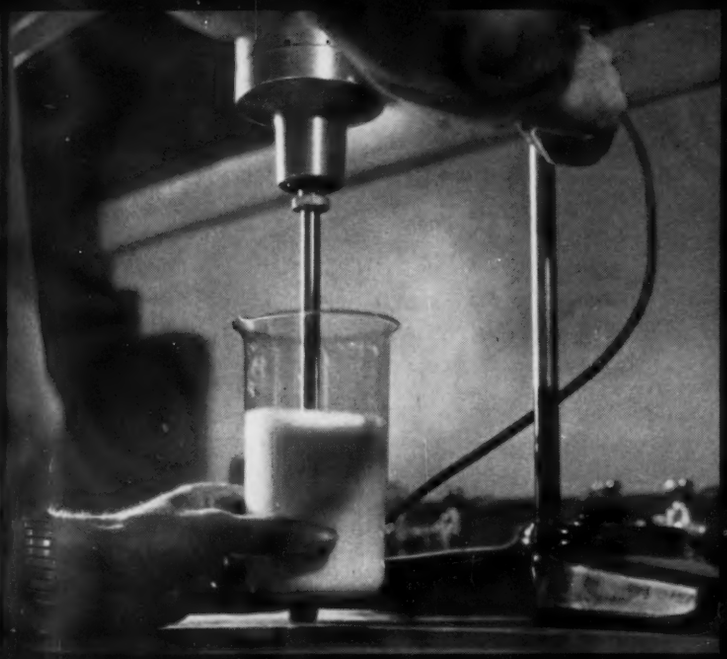
Compatibility with seals, metals eases fluid installation—PYROGARD C fire-resistant fluid is easily installed because it has no adverse effect on most packings, seals, or hoses, and is non-corrosive to metals normally found in mill hydraulic systems. Containing effective rust inhibitors, PYROGARD C fire-resistant fluid gives excellent protection against rusting wherever it contacts metal.

POSITIVE HYDRAULIC RESPONSE...

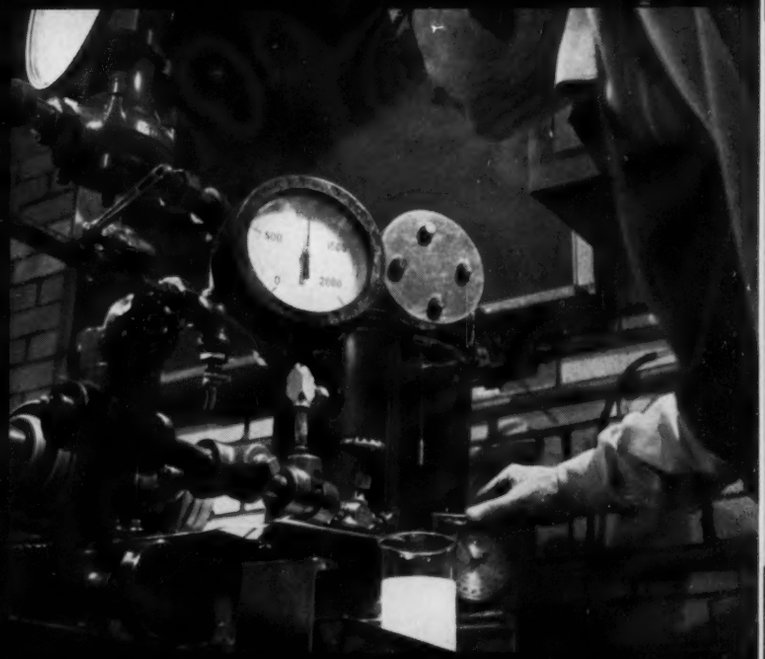
Now, the makers of world-famous Mobil petroleum hydraulic oils bring you PYROGARD C, a new fire-resistant fluid that offers positive hydraulic response plus improved plant safety . . . at low cost.

PYROGARD C fire-resistant fluid is a water-in-oil emulsion containing special chemical addition agents. It's been thoroughly field tested in actual service . . . will give excellent performance under conditions such as those encountered in press welders, furnace-door openers, ladle-tilting mechanisms, scrap balers, and die-casting machines.

The major benefits provided by PYROGARD C fire-resistant fluid are detailed below. In addition you receive the help of experienced Mobil Engineers in applying it to your equipment. Their specialized know-how in the installation and maintenance of fire-resistant fluids will make the procedure sure and simple. Examine the benefits of PYROGARD C fire-resistant fluid —then contact your nearest Mobil Representative.



Long-term stability in storage and use assures uninterrupted production—PYROGARD C fire-resistant fluid is highly stable even at higher-than-normal temperatures—resists breakdown, foaming and water separation—keeps pump parts and screens free of deposits. And with PYROGARD C, water evaporation is retarded by a thin oil skin that forms when the emulsion is at rest, yet readily remixes when fluid is agitated (shown above).



Unusual flow properties assure positive hydraulic response, yet reduce leakage—PYROGARD C fire-resistant fluid has unusual viscosity characteristics . . . resists leakage at static joints, yet gives rapid flow and response elsewhere in the system. In apparatus above, a specially designed "leak chamber," introduced into hydraulic system, shows the PYROGARD C leaks less than ordinary hydraulic oil.

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and for America's
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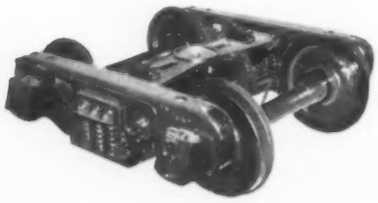
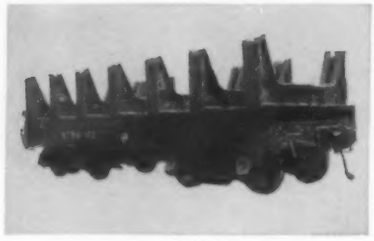
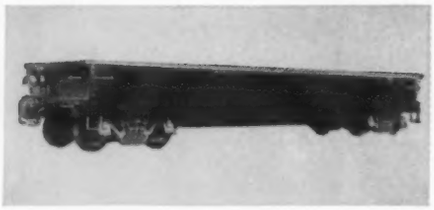
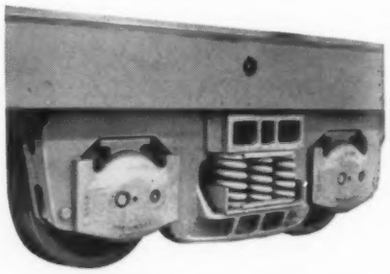


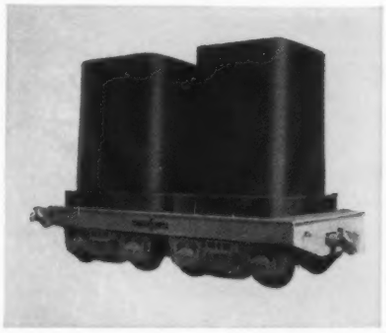


■ *Type "A" Truck*, with 36 load springs per truck, is fully proven in extra heavy duty service on cradle, slab and crop cars. Quick, easy replacement of separable journal boxes in the event of damage, or can use arch bar type journal boxes in emergency.



■ *Type C-1 Truck*, approved by AAR, is volume-produced at low cost. Flexible design accommodates friction bearings (including flat-back type that will not slip during re-railing) or roller bearings. Quick wheel (33″ or 36″) and axle change. No spring planks required.





■ *Industrial Trucks* of many special kinds designed to meet all load requirements and, where possible, interchangeable with present equipment. Feature unique combination of patented rapid wheel and bearing change, lighter bearing loads, balanced stress distribution. A-5078A

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Alan Wood Dedicates New Plate Mill

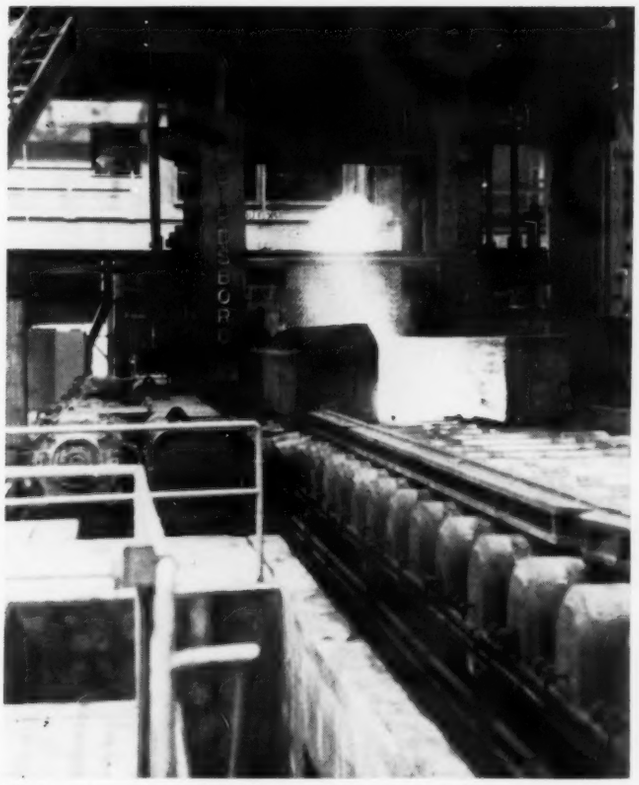


Figure 1 — The 40-in. blooming mill features auxiliary screws to carry the top roll and eliminate the need for counterbalance weights or a hydraulic system.

TWO of the world's most modern rolling mills, a 40-in. blooming mill and a 110-in. plate mill, were officially placed into operation on November 1 by Alan Wood Steel Co. Part of a $36,000,000 expansion and modernization program, the new facilities will enable the company to produce steel plates up to 96 in. wide compared with outside width limits of 72 in. previously.

The new mills will markedly alter the composition of Alan Wood's product mix. As a result of the new facilities, Alan Wood's product mix will be comprised of more than 40 per cent plates—with the balance about evenly distributed between hot and cold rolled sheets.

First planned in 1959, construction of the new facility was commenced in early 1960.

A new mill building, over 1000 ft in length in order to provide a continuous production flow, is actually divided into two areas. First is the 40-in. blooming mill section where ingots are rolled into blooms or slabs on the new 40-in. blooming mill.

Figure 2 (left) — Alan Wood Steel Co.'s new blooming mill and plate mill were built as a major part of a $36,000,000 expansion program. The new facilities provide for production of wider and thicker sizes of steel plate and improved product quality.

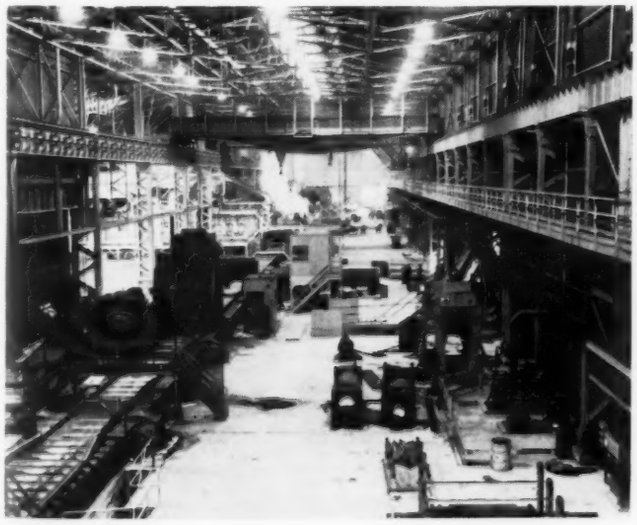
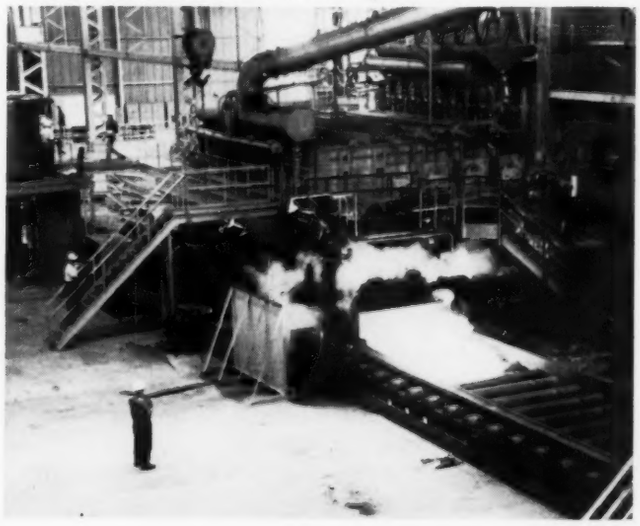


Figure 3 (right) — A 3-zone, pusher-type, continuous slab-heating furnace provides a firing rate of 1,650,000 Btu per ton and will heat 140 tons of slabs per hr.



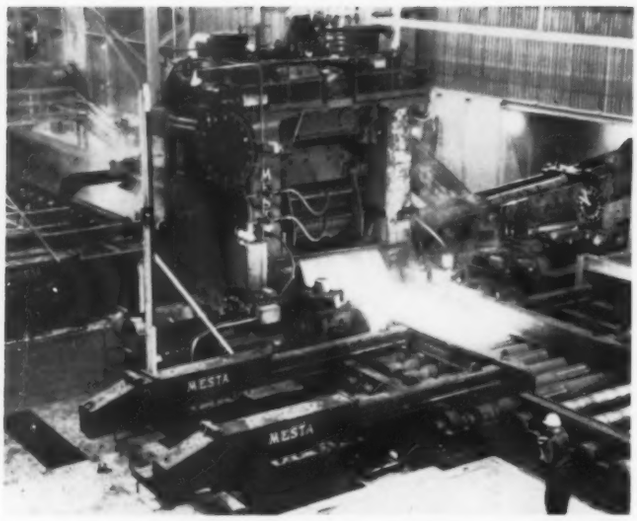


Figure 4 (left) — The 110-in., 4-high reversing mill uses water sprays applied at 1500 psi.

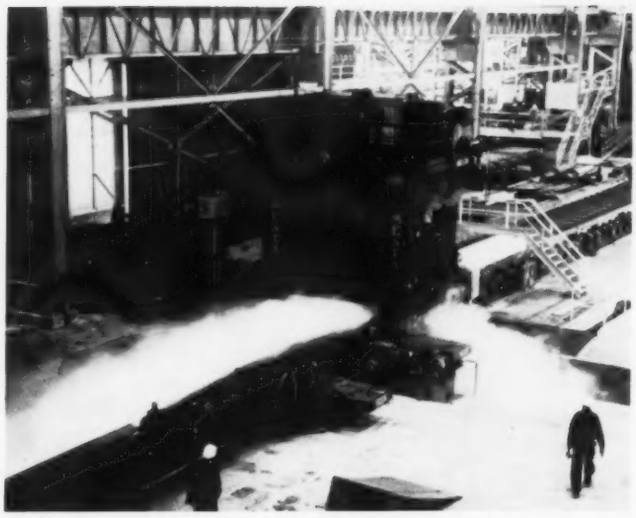


Figure 5 (right) — The nonreversing mill provides a finish pass for flat surface plates, or applies the "AW" Super Diamond pattern to Alan Wood's specialty-steel floor plate. The 4-high mill has the same size backup and work rolls as the reversing mill and is driven by a 5000-hp, 240-rpm motor.

Built by Birdsboro Corp., the blooming mill stand consists of a 40 x 96-in. high-lift bloomer with 12, 8 and 4-in. edging passes and a $62\frac{3}{4}$-in. wide bullhead with a total lift of 60 in. It is powered by two 3000-hp, 700-volt, 0/40/80-rpm General Electric motors and reversing time is 1.5 sec, base speed to base speed. The main mill motor-generator set has two d-c generators of 2500 kw, 700 volt, 514 rpm and a wound-rotor induction motor rated at 4500 hp, 6600 volt, 3 phase, 60 cycle, 514 rpm. Rolls are changed with a mechanical sled-type changer.

The slab shear is a 1200-ton up-and-down cut type driven by a 250-hp, a-c motor. It has a capacity of 432 sq in. (8 x 54 in.) at a speed of 8 cuts per min. Shear knives are 65 in. long by 2 in. by 8 in. A gage table adjusts for shearing slab lengths from 5 to 25 ft. Slabs are individually weighed and then transferred by a slab car to the conditioning yard. Crops are moved by car up an incline from a huge, specially-built pit under the slab shear and dumped into railroad cars for remelting in the company's open hearths.

Slabs to be rolled in the 110-in. mill are reheated to rolling temperature in a slab reheating furnace built by Rust Furnace Co. This is a pusher-type, 3-zone, 4-skid furnace with a 78-ft effective length, including a 19-ft dry hearth, and an inside width of 26 ft. Twenty-six combination oil-gas burners have a firing rate of 1,650,000 Btu per ton and will heat 140 tons of slabs per hr. A 5-unit metallic recuperator furnishes preheated air for combustion. Scale developed on the slab during reheating is removed at a 2-high Mesta scalebreaker with 36 x 66-in. rolls driven by a 1200-hp constant-speed motor through a pinion unit.

Heart of the operation is a 110-in., 4-high reversing mill, also built by Mesta Machine Co., which reduces slabs to plates. Two housings weighing 160 tons each, have window openings 4 ft-10 in. wide by 16 ft high. Backup rolls are 54 in. diameter by 109 in. long with 33-in. diameter tapered necks, while work rolls are 36 in. diameter by 110 in. long with 22-in. neck diameter. The reversing mill is driven by two 4000-hp Westinghouse motors. A motor-generator set furnishes d-c power through two Westinghouse motors of 3500 kw, 700 volt each and driven by an 11,000-hp, 360-rpm, 3-phase, 60-cycle, 6600-volt-synchronous motor which also drives a 1250-kw, 700-volt generator for the vertical edger stand motor.

From the reversing mill, plates are transferred to a 110-in. Mesta nonreversing mill which provides a light draft finishing pass and applies the "AW" Super Diamond pattern to Alan Wood's specialty-steel floor plate. Mill is driven by a 5000-hp, 240-rpm, a-c, 5900-volt motor through a gear reduction unit and pinion stand.

Scale formed on the slab surface is removed by a hydraulic water spray system using 1500 psi, positioned at the delivery side of the scalebreaker and entry sides of the reversing and nonreversing mills. The scale drops into flumes or trenches which are equipped with a water flushing system. Scale is flushed into pits and crane bucketed out of pits into railroad cars.

Long plates are sheared to suitable lengths on a 700-ton up-and-down cut shear furnished by Birdsboro. It is driven by a 100-hp motor and has a capacity of $1\frac{1}{2}$ in. by 100-in. plate at 8 cuts per min.

From the parting shear plates are moved by transfer table to the 110-in. shear line. In this area they are hot leveled, cooled, and sheared to length and width; after which plates are stacked and weighed prior to being trucked to the plate finishing and shipping department.

Shear line equipment includes a $\frac{3}{16}$ to $1\frac{1}{2}$-in. Birdsboro hot leveler; two $1\frac{1}{2}$ in. thick by 100-in. width capacity, up-and-down-end cut shears built by Birdsboro; and a United Engineering and Foundry Corp. rotary side trim shear able to handle finished plate from 34 in. to 104 in. wide and $\frac{3}{16}$ in. to $\frac{3}{4}$ in. thick. Plates are transferred to the plate finishing and shipping department by three 20-ton capacity straddle trucks.

In the plate finishing and shipping department, plates are sorted, inspected, resheared and loaded for shipment to customers. ▲

John Shultz and Mike Paronjack Are Monitoring 20 Reversing Rooms

At the Clairton plant of U. S. Steel Corporation, reversals on 20 coke oven batteries are observed from a central monitor room by two monitor operators.

Observation is *continuous*—the men in the monitor room know conditions in all reversing rooms between reversals as well as during reversals. Travel of heater helpers from one reversing room to another is eliminated.

A Femco Audio Tone System telemeters gas pressure and stack draft pressure from the reversing rooms to the monitor room. A Femco Circuit Scanner system transmits indications of "Gas On" at the pusher side, "Gas On" at the coke side and power condition at the reversing machine.

If any abnormal condition arises, the monitor operator can activate an emergency alarm. This can be shut off only by a confirmation button in the reversing room, which also transmits a signal to the monitor room.

The complete monitor system is made up of 149 signals, 47 of which are telemetering functions and 102 are monitoring and control. For signal transmission, batteries are combined in groups of four, and all signals to and from each group are handled over a single pair of wires.

We will be glad to give you further information about systems for centralized monitoring of reversals or about the many other Femco systems in use in the metals industry. These include not only telemetering and monitoring but also remote and automatic control of quench cars, soaking pit covers, ingot buggies, electric mules, overhead cranes, and many others.

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COMMUNICATIONS: Carrier and wired audio systems for all mining and industrial applications. **MONITORING:** Fans, circuit breakers, valves, pumps, compressors, etc. **TELEMETERING:** Flows, pressures and other functions. **REMOTE CONTROL:** Pumps, valves, circuit breakers; soaking pit covers, furnace doors; cranes, or other moving equipment.

Lou Krakowski, General Superintendent of the Harrison Sheet Steel Company, is a guy who makes no bones about what he wants. It's service! And, for twenty years, he has been getting what he considers the best . . . Cities Service.

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Detection Equipment Combines Novel Magnetic Variations and Modular Construction

COILS of Alumoweld wire are butt welded together at the Copperweld Steel Co. in Glassport, Pa., so that they can be drawn continuously through several dies in one operation. Each of these welds is recognized as an undesirable area from a metallurgical point of view and is cut out of the finished product. Although Copperweld had been marking these areas with an identifying colored dye and many times re-marked them as the wire was drawn at speeds in excess of 1000 fpm, it was not a satisfactory method of detection. Now, these butt-welded areas are being spotted positively by Flux-Flaw equipment developed by Assembly Products, Inc., of Chesterland, Ohio.

Although Copperweld is using the equipment only in connection with wire, other companies have carried out extensive tests on sheet and tubing. The equipment, which employs new principles in the detection of discontinuities, has been notable for its ability to distinguish between the type of discontinuity it was seeking and other phenomena that might cause unwanted signals or "noise." Since the first unit was installed at Copperweld, the company has ordered three more units.

This equipment provides several methods of detection in each basic unit. At Copperweld d-c excitation is employed in an induction technique which picks up magnetic discontinuities in the steel and these alter the magnetic field surrounding the wire. Previously, Copperweld engineers found that conventional eddy current techniques would not distinguish positively between welds in the steel and slight irregularities in the wire. The eddy current principle involves a-c field excitation and the tendency is for this to be absorbed by the sample being tested.

At Copperweld, the detection units are being installed on four wire-drawing machines each of which has four or more die blocks.

Just before the wire is coiled at the end of the run, it passes through a pickup transducer mounted on a die box. The transducer signals the control cabinet, mounted nearby, when a weld comes along. Eventually, this signal will be used to stop the machine so that the wire can be cut. However, during the initial testing period, alarm bells are actuated by signals from welds.

The unit transducer incorporates coils, surrounding the wire, which are energized with direct current to create a steady magnetic field. Also, in each transducer are identical pickup coils, positioned so that each

Figure 1 — The detection unit is easily mounted wherever the existing equipment permits, as a flexible cable is the only connection necessary between the unit and the control cabinet.

"watches" a different section of wire at any given moment. When the magnetic field is changed by a "condition" passing through it, a voltage proportional to the rate of change is induced in the pickup coils. These signals are then compared and the difference between them is amplified into a useable signal that truly indicates a weld. Noise signals are picked up equally and simultaneously by both coils.

With this sensing technique, nonmagnetic materials, such as aluminum coating, do not confuse the detection system, even when these materials are electrically conductive. Similarly, detection ability is not affected by changes in a nonmagnetic core material, by radial movement of the wire within the pickup coils, nor by velocity of the wire.

Instead, the induction technique is highly sensitive to abrupt changes in magnetic properties, such as welds, sudden changes in cross section, and changes in hardness or composition. The system is also somewhat sensitive to accelerations of the sample, but this unwanted type of signal generally can be effectively eliminated mechanically if significant in a particular setup.

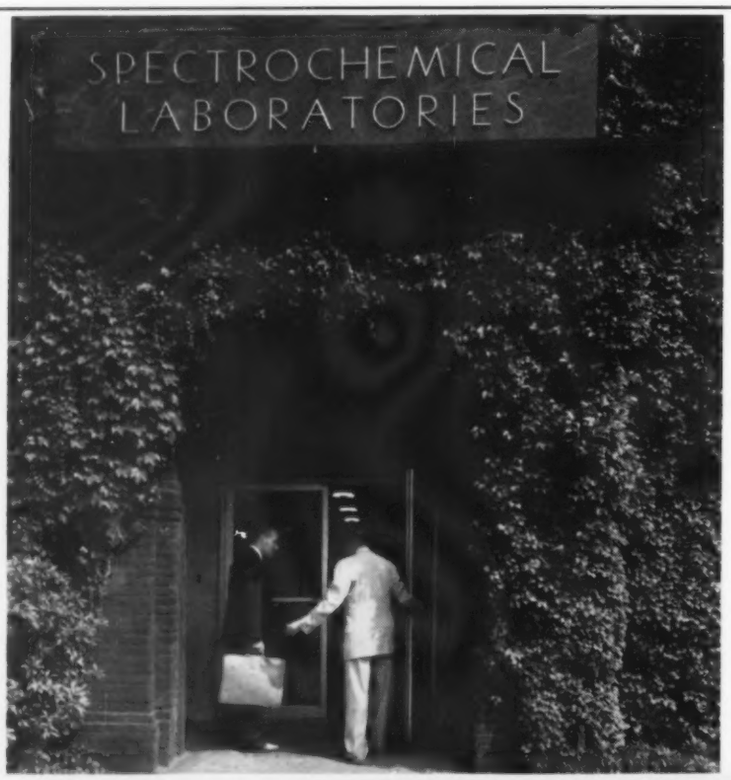
Signals from the two pickup coils in each transducer are separately amplified and fed to a difference detector. The signals are balanced so that the single output from the detector is minimized when no flaw is present. This difference signal is amplified in turn before being fed to a vacuum-tube voltmeter that actuates a zero-center meter relay. The meter relay has two adjustable contacts (mounted on pointers) set at high and low levels that are reached by signals whose magnitudes indicate welds. When a set point is reached, the meter-relay contacts lock firmly and close a circuit to a load relay which triggers an alarm or a machine shutoff. Noise signals are continuously visible on the meter-relay dial, although these signals do not reach set points.

The meter relays are used as triggering devices because they are electromechanical and inherently stable. Purely electronic triggering devices were tried, but they tended to drift and thus change the relationship between signals and noise.

In addition to the induction technique used at Copperweld, other Flux-Flaw approaches to flaw detection have been developed to meet a variety of problems. Through use of plug-in electronic modules, a basic unit may be quickly adapted to different uses. Modular design also permits servicing units without removing the cabinet from its permanent location.

For example, such equipment can also be arranged to use the common internal reference eddy current technique, which has great sensitivity and is the simplest approach to certain problems. The simplicity and stability of the meter-relay output arrangement are important advantages in this case.

Another innovation, in commercially available equipment, is a capacitive sensing technique. It is chiefly useful for detecting changes in surface area that may be caused by pits, flake-off and other abrupt blemishes. In this detection system electrically conductive samples are passed through holes in solid tubular electrodes which are the opposing arms of a capacitive bridge. ▲



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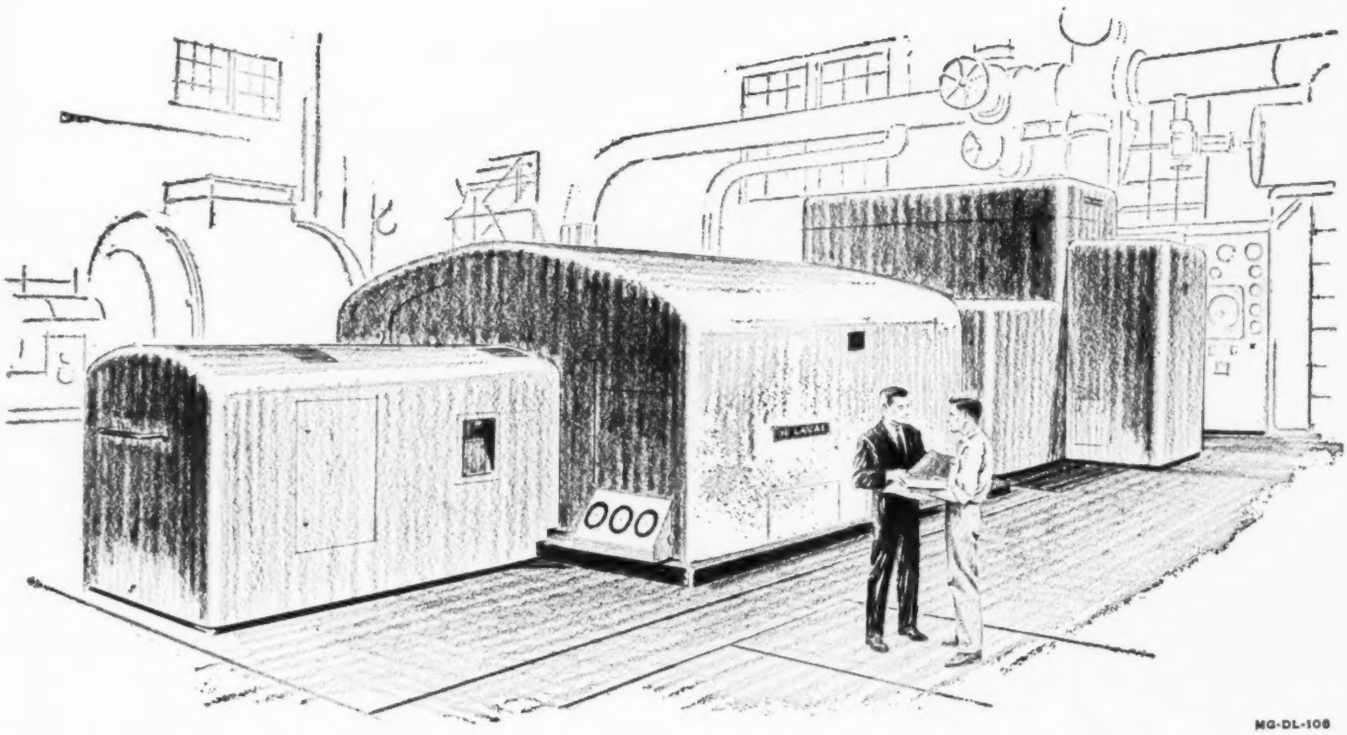

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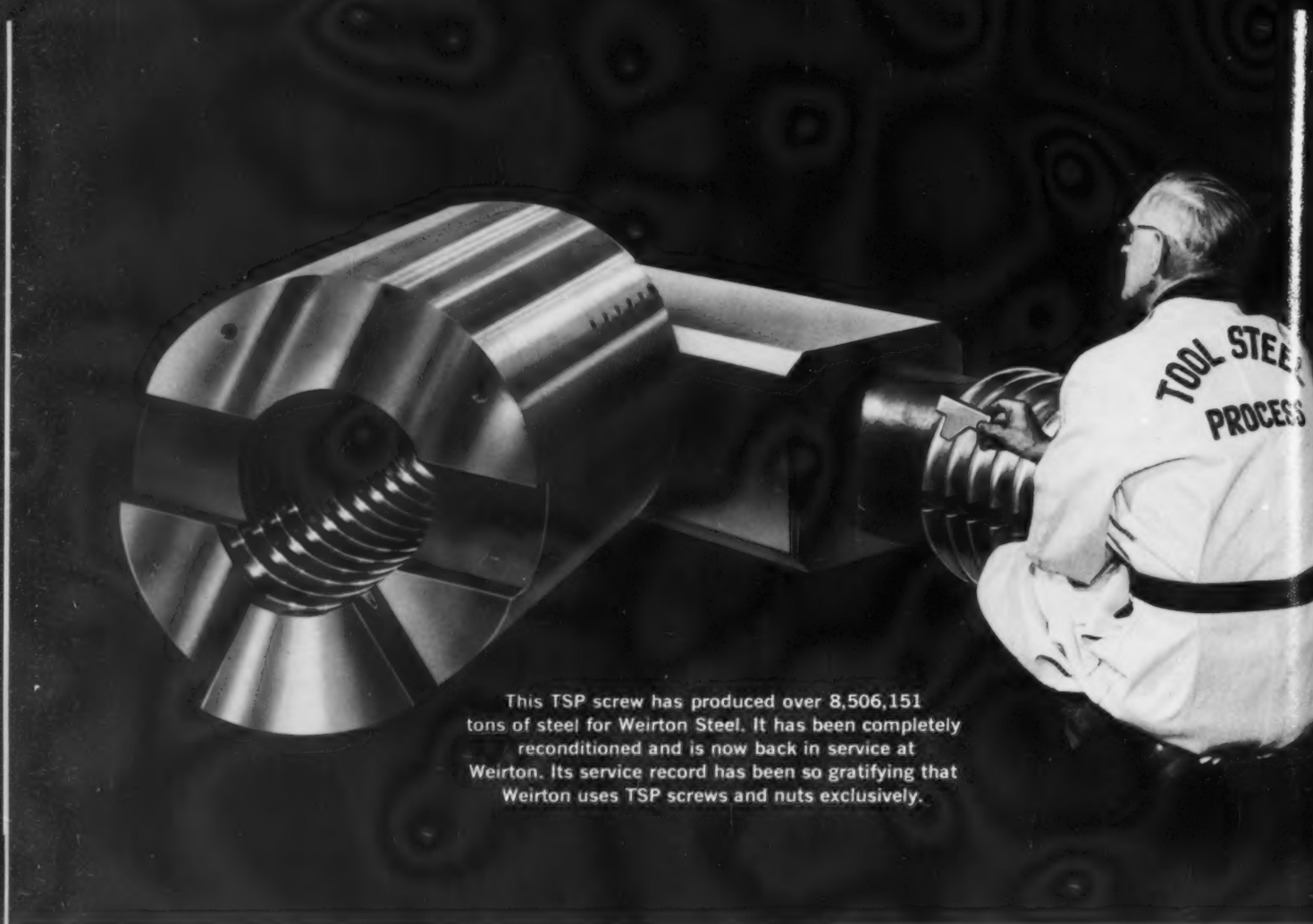


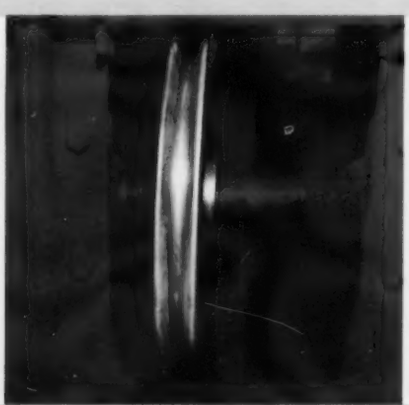
This TSP screw has produced over 8,506,151 tons of steel for Weirton Steel. It has been completely reconditioned and is now back in service at Weirton. Its service record has been so gratifying that Weirton uses TSP screws and nuts exclusively.

TSP screws and nuts

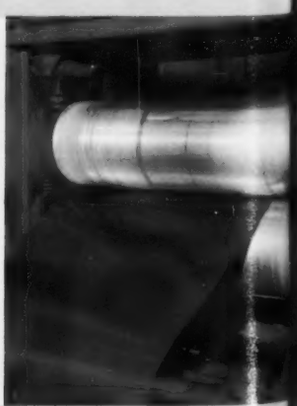
Almost nine million tons of steel have been produced with this "Tool Steel Process" screw and nut installed in 1955 at The Weirton Steel Co., division of National Steel Corporation, Weirton, West Virginia. This phenomenal performance record is characteristic of the results Weirton Steel has been getting with all TSP products in their plant. The result is great savings in maintenance, replacement and downtime costs. In addition to screws and nuts, TSP hardened products now in constant use throughout National Steel Corporation's many plants include cold rolling rolls, leveller rolls, cold processing rolls, all types of gears and pinions, drum sleeves, track wheels, sheave wheels, shafts, axles, and other miscellaneous hardened products. All TSP products have a file hard surface to the full depth of permissible wear for maximum life. The core, refined for toughness and ductility, gives maximum strength. Every TSP hardened product is positively guaran-

TSP hardened products have been used at Weirton Steel since 1928

TSP track wheels on slab yard crane.



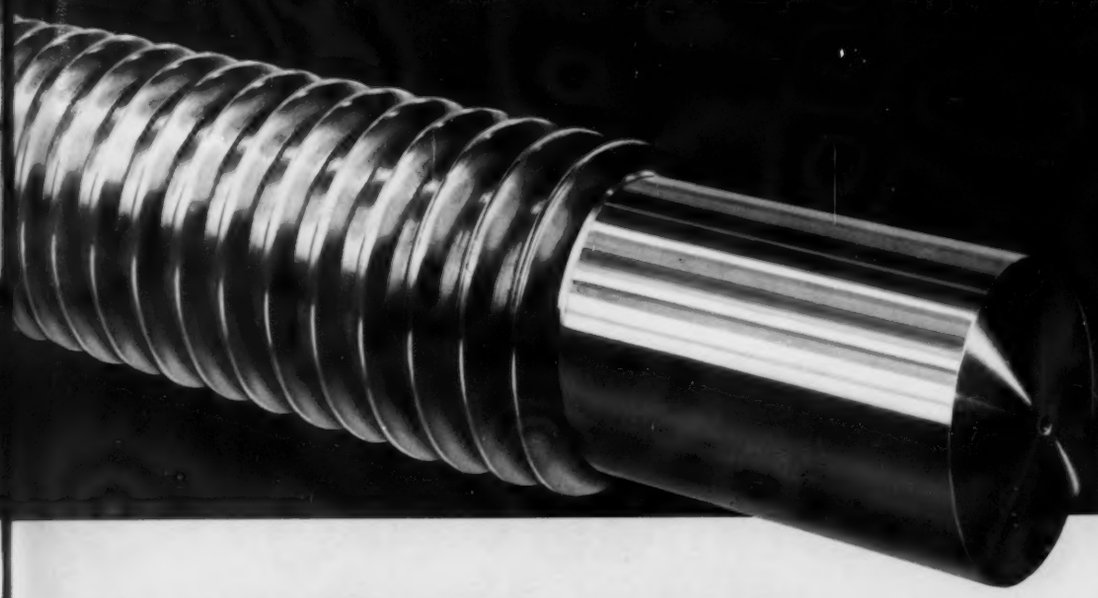
TSP sheave on coke hoist shows no wear after 28 months service. Competitive sheaves lasted 8 months.



TSP pinch rolls on tin mill cleaning line.

MILLIONS IN TONS

only pennies in maintenance



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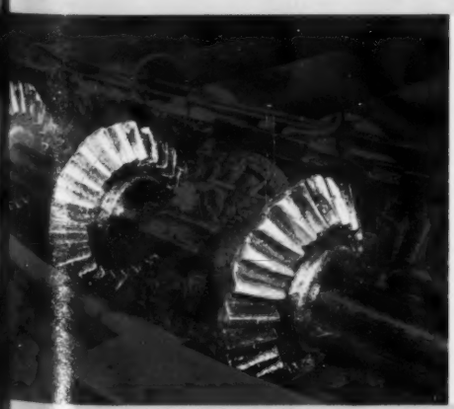
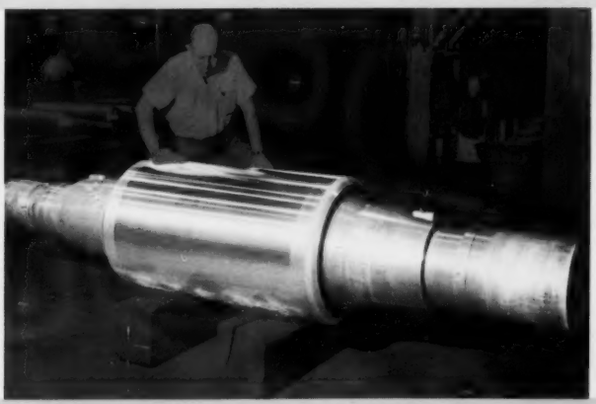


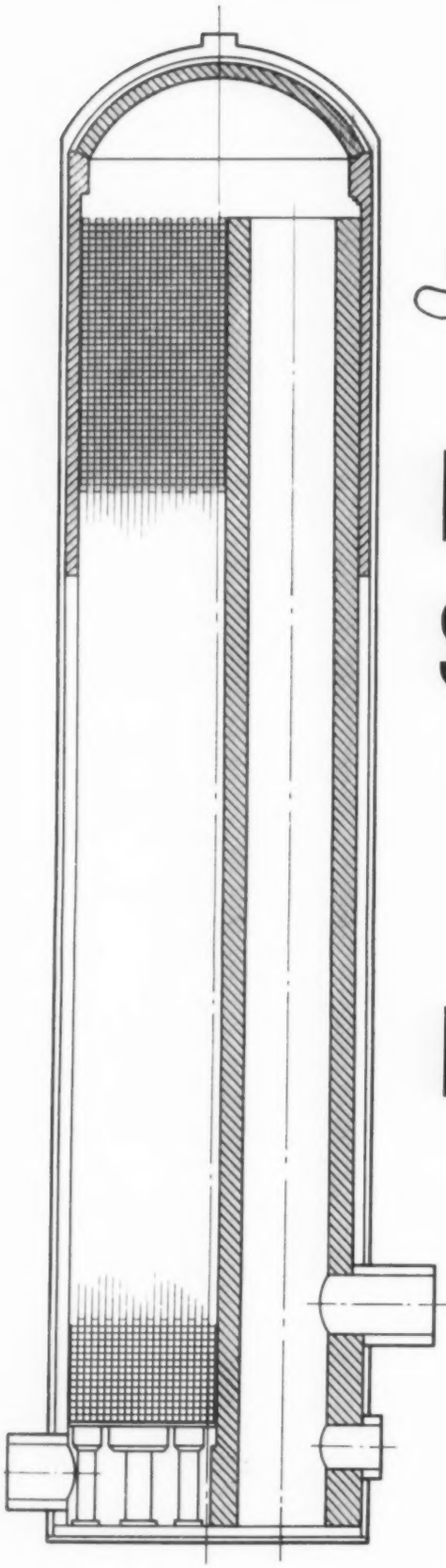
TSP bevel gears average 3 times life of competitive gears.



TSP 27½" x 45⅝" forged steel temper mill roll rehardened and ground and ready for further service.

TSP rope drum sleeves.

AD 1035-A Printed in U.S.A.



A two-pass blast furnace stove with application of TAMUL brick and shapes shown in gray.

Increasing hot blast temperatures?

REINFORCE CRITICAL STOVE AREAS WITH TAMUL BRICK AND SHAPES!

Major blast furnace operators planning on increasing hot blast temperatures (to as high as 2000° F.) are now constructing stoves with dome, upper checkers, upper sidewalls, and combustion well walls of TAMUL (Taylor synthetic mullite) brick and shapes.

Excellent resistance to thermal spalling, alkali attack, and subsidence under long-term hot load, along with high refractoriness (P. C. E. — Cone 39) combine to make TAMUL the ideal refractory for these trouble spots. TAMUL should be laid up in new, improved TASIL cement.

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Pipe Measurement System Functions Automatically

THE development of a new system for automatic weighing, measuring and identification of heavy oil-field pipe has been announced by Baldwin-Lima-Hamilton Corp.'s Industrial Equipment Div. Additional applications are anticipated wherever tubular or flat mill products must be measured, weighed, counted, marked or recorded before shipment.

The system is believed to be a major step toward the eventual full automation of pipe mills and toward the automatic loading of boxcars, where pipe must be segregated within narrow tolerances.

The system processes a pipe section every 18 to 36 sec.

Pipe, accepted in lengths to 50 ft-2 in. and in 4½ to 10½ in. diameters, has its length measured to an accuracy within plus or minus ½ in., is weighed to within 0.1 per cent and is stenciled automatically. The machine prints a record for each individual pipe. It also counts total pieces, computes weight per ft, indicates and prints total accumulated weight and length.

Only one part-time attendant is needed, compared with the four to eight man crews formerly required for weighing, measuring, tallying and stenciling.

The machine measures 65 ft in over-all length. It consists of a complete mechanical installation for mill handling of heavy pipe, a special-purpose computer and instrumentation and controls.

The new system incorporates marked advances, which are reflected both in more rugged design of all mechanical components, and in an improved system of electromechanical instrumentation, developed and supplied to B-L-H specifications by Telechrome Manufacturing Corp.

The instrumentation, especially developed for steel mill conditions, is of modular design throughout. Relays, visual read outs for each digit, programming switches and all other components are sealed in heavy plug-in cases, permitting simple replacement of instrumentation by regular mill operators.

A signal board locates any trouble instantly. Lighted indicators sequence automatically with each weighing, measuring, computing and recording cycle, and show the unit at fault if there is a malfunction in instrumentation or control.

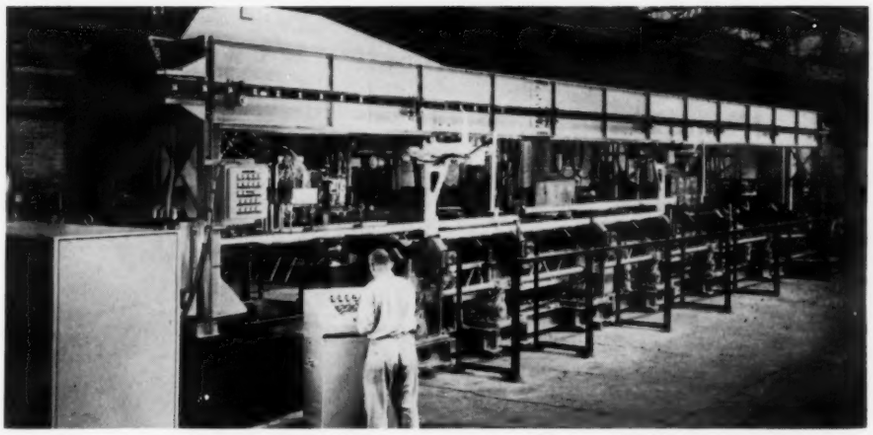

Figure 1 — The system will handle pipe up to 10¾-in. OD and up to 50 ft-2 in. long.

Pipe entering the system is picked off loading arms by a synchronized transfer mechanism. Entering the first of two stations, it is supported for length measuring, weighing and counting. Arms move up against the ends of the pipe and a servo system translates the distance the feeler arms move into an electrical signal proportionate to length.

Weight is then checked by B-L-H load cells with null balance detecting system.

From the weigh bridge, the pipe moves to the second station. Here, stenciling is done automatically from an overhead, air-operated platform. Weight, length and other abbreviated specification data is marked, in accordance with API code requirements.

A memory device permits processing of two pipes at once, with stenciling of one pipe taking place while a second pipe is being measured and weighed.

When the fully-transistorized computer determines that the pipe does not comply with API specifications, the system is automatically stopped, and a visible audible alarm signals the operator.

Electrical signals may be initiated at preset values of count, for total or individual weight or length, or at an upper or lower limit of tolerance on the computed weight per ft or other desired quantity. These electrical signals can be used to operate relays, alarms, reject devices, close down the line, or meet other individual requirements.

Providing an instant backcheck on previous processing states, the machine gives a direct read out of weight or other measured or calculated quantities, in illuminated letters one in. high, clearly visible from a distance.

The automatic recorder provides up to nine clear printed copies of the tabulated data, to meet the requirements of inventory control, accounting, order control and other administrative departments.

A Farval automatic lubrication system is incorporated in the weighing-measuring-stenciling machine.

The API code requires that heavy oil-field pipe meet certain specifications: that weight per ft and other data be stenciled onto pipe.

This API code requires that weight be held within plus 6½ per cent to minus 3½ per cent of nominal weight per ft, but the weight of the total footage of pipe on an order cannot vary from nominal by more than 1½ per cent, and still meet API carloading requirements for shipping. Also, no more than five per cent of short lengths can be loaded in any one car. The new, more accurate electronic weighing and measuring system substantially eliminates the tedious and costly job of segregating pipe to meet these shipping requirements. ▲

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Keep your steel operations flexible by removing all uncertainties about oxygen supply with an Airco tonnage oxygen plant. A plant we build and operate for you — on or adjacent to your site — gives you assurance of supply that only an experienced oxygen producer like Airco can guarantee.

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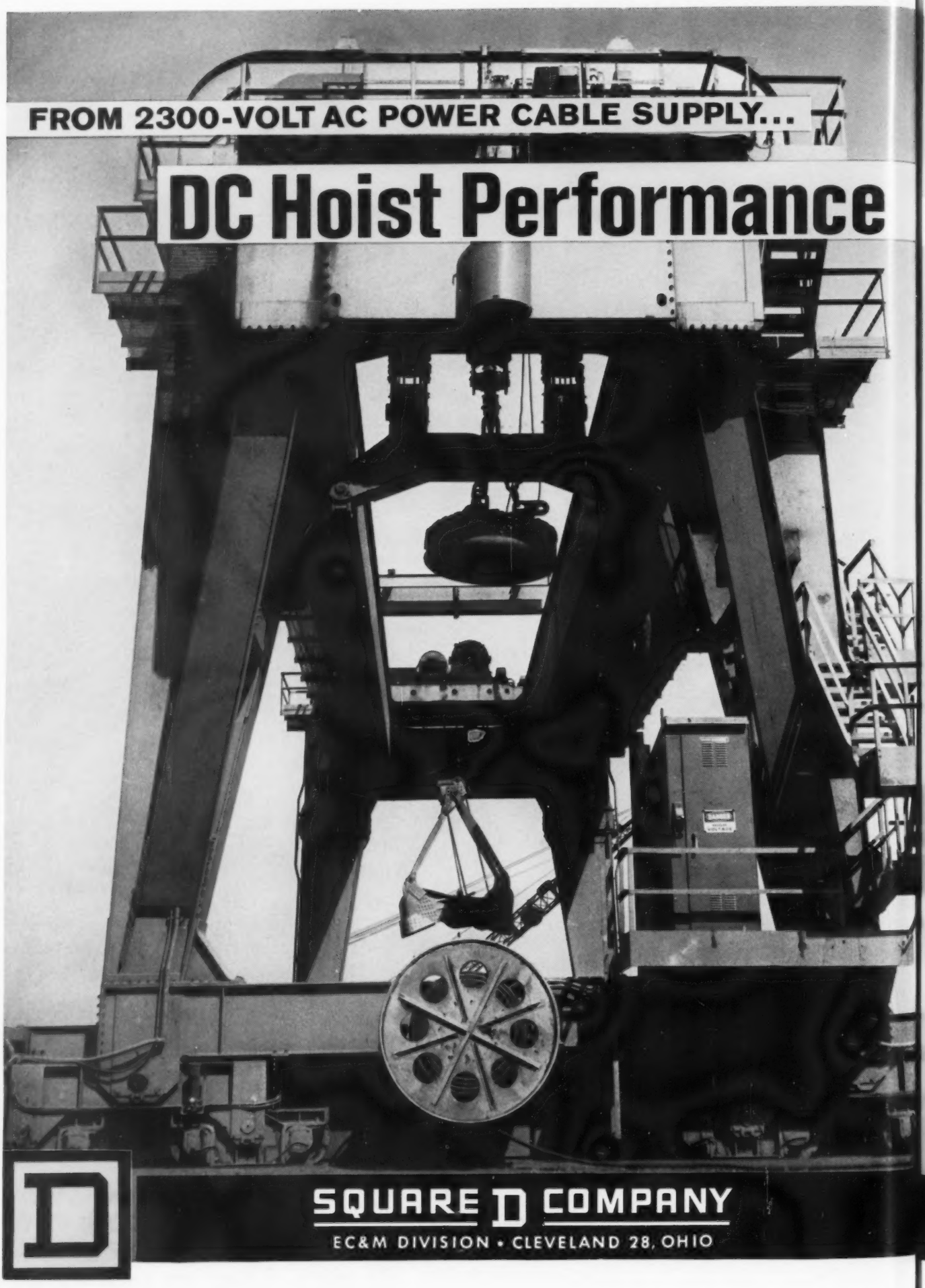

FROM 2300-VOLT AC POWER CABLE SUPPLY...
DC Hoist Performance
SQUARE D COMPANY
EC&M DIVISION • CLEVELAND 28, OHIO

with greater economy, simplicity and safety!

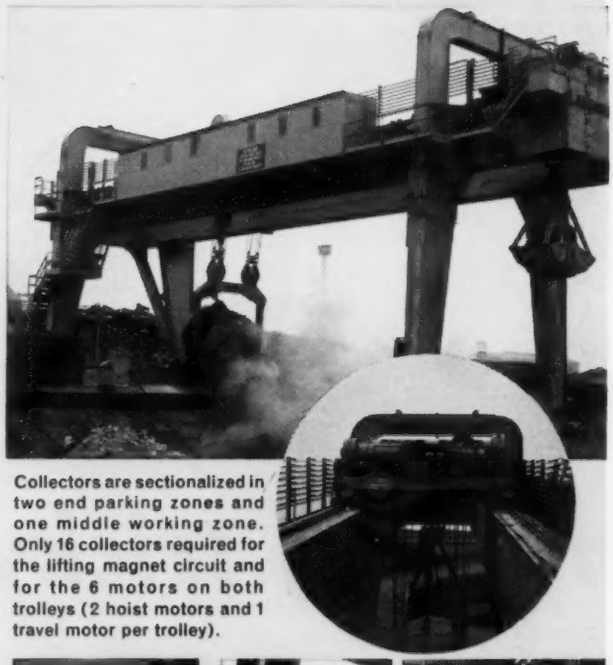
You get these exclusive advantages with EC&M's Type HWR Control–

- *DC hp less than the AC counterpart*
- *40% fewer collector bars*
- *No load brakes*
- *No rotary converters*
- *Simpler installation*
- *Easier maintenance*
- *Uses series motors and series-wound hoist brakes*
- *Unequalled safety of the EC&M Wright Hoist Circuit*

This double trolley (100/30-ton hook and 20-ton bucket) gantry crane was built by Cleveland Crane and Engineering Company. It is used for efficient slag handling by Heckett Engineering Company at the East Chicago, Indiana, plant of Inland Steel.

EC&M Type HWR controllers for the hoist motions were selected for their ability to handle the wide load range of slag-pot, bucket and magnet. Trolley motors are operated by EC&M frequency relay controllers. An EC&M quadruplex frequency relay controller operates the four gantry travel motors in unison.

Before buying AC cranes, ask the crane builder about the proved advantages of EC&M Type HWR Control.



Collectors are sectionalized in two end parking zones and one middle working zone. Only 16 collectors required for the lifting magnet circuit and for the 6 motors on both trolleys (2 hoist motors and 1 travel motor per trolley).

Incoming line cubicle includes 2300-volt disconnect switch and 2300/220-volt transformer as well as 220-volt manual-magnetic disconnect switch.

EC&M Type VM master switches require minimum mounting space in cab. Controllers are mounted in walk-in control house on bridge footwalk.

***Write** for Brochure 6414 — it describes and illustrates HWR control in detail*
Square D Company, EC&M Division, 4500 Lee Road, Cleveland 28, Ohio

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Date-line Diary...

November 1

Δ The Bureau of the Census reported that shipments of nonferrous castings in the U. S. in August, 1961, totaled 186,806,000 lb, compared with 134,574,000 lb in July, 1961.

Δ The Japan Iron & Steel Federation reports that production of pig iron in Japan in August, 1961, totaled, 1,486,100 net tons; production of ingot steel totaled 2,699,400 net tons.

November 2

Δ The Census Bureau reported that U. S. exports of civilian merchandise in September, 1961, totaled $1,613,200,000, after seasonal adjustment, down two per cent from the August, 1961, level.

Δ The American Iron Ore Assn. reports that U. S. shipments of iron ore down the Great Lakes in October, 1961, totaled 7,829,759 gross tons, compared with 6,676,116 tons in October, 1960.

Δ American Iron Ore Assn. and AISI jointly report that receipts of iron ore and iron ore agglomerates in the U. S. in September, 1961, totaled 12,116,028 gross tons, compared with 11,048,599 tons in September, 1960. Consumption in September, 1961, totaled 8,964,553 tons, compared with 6,356,018 tons in September, 1960. Of the existing 255 blast furnaces, 160 were operating on September 30, 1961, compared with 136 on September 30, 1960. For the third quarter, 1961, receipts totaled 38,331,774 tons, compared with 40,647,714 tons in the same period, 1960; consumption in the third quarter, 1961 totaled 26,249,299 tons, compared with 20,099,049 tons in the third quarter, 1960.

November 3

Δ The Treasury Dept. said it will undertake no additional cash borrowing to increase the national debt during the remainder of the fiscal year ending June 30, 1962.

November 4

Δ The AISI reports that production of steel for the week ending November 4, 1961, totaled 2,044,000 net tons (about 71.7 per cent of capacity) compared with 2,057,000 tons one week ago (72.2 per cent of capacity) and 1,478,000 tons one year ago. Index of production was 109.7.

November 6

Δ Labor Dept. reported that unemployment in the month to mid-October totaled 3,900,000, down 151,000; employment in October to the 15th totaled 67,800,000, up 800,000.

Δ The Bureau of the Census reports that shipments of iron and steel castings in August, 1961, totaled 1,098,945 tons, compared with 925,152 tons in July, 1961, and 1,018,997 tons in August, 1960.

Δ The Bureau of Mines reported that production of Pennsylvania anthracite in October, 1961, totaled 1,709,000 net tons, compared with 1,423,000 tons in September, 1961 and 1,678,000 tons in October, 1960.

Δ The AISI reports that shipments of electrolytic tin plate for the first three quarters of 1961 totaled 4,296,538 net tons, compared with 4,279,724 tons in the same period, 1960. Shipments of finished steel products from mills in the first three quarters of 1961 totaled 48,544,475 net tons, compared with 57,612,825 tons in the same period, 1960.

November 7

Δ Pittsburgh Coke & Chemical Co. reports 1961 third quarter sales totaling $15,740,000, net earnings of $609,000, equal to 43¢ per share, compared with 1960 third quarter sales of $15,068,000, net earnings of $308,000, equal to 17¢ per share. For the first nine months of 1961, sales totaled $38,625,000, net earnings amounted to $29,000, equal to a loss of 25¢ per share after preferred stock dividends, compared with sales totaling $49,738,000, net earnings of $1,423,000, equal to 95¢ per share, in the same 1960 period.

November 8

Δ The AAR reported that net income of Class 1 roads rose to $41,000,000 in September, 1961, compared with $26,000,000 in September, 1960.

Δ The Bureau of Statistics reported that Canadian steel production in October, 1961, totaled 572,393 tons, compared with 479,069 tons in October, 1960; pig iron production in October, 1961, totaled 458,791 tons compared with 368,043 tons in October, 1960.

November 10

Δ The AISI reports that the steel industry's payroll for hourly and salaried workers in September, 1961, totaled $332,608,633, compared with $336,819,552 in August, 1962, and $287,182,482 in September, 1960. Total employment in September numbered 550,524 compared with 545,293 in August, 1961, and 531,111 in September, 1960. Payroll cost per hr worked by hourly employees was $3.486 in September, 1961, compared with $3.447 in August, 1961, and $3.342 in September, 1960, not including 50¢ an hr supplemental employee benefits. Average hours worked per week were 37.3 in September, 1961, compared with 37.8 in August, 1961.

Δ The Dept. of Commerce reported that retail sales in October, 1961, totaled nearly $18,600,000,000, after adjustment for seasonal trend, up two per cent over the September level.

November 11

Δ The AISI reports that production of steel for the week ending November 11, 1961, totaled 2,046,000 net tons (about 71.8 per cent of capacity) compared with 2,044,000 tons one week ago (71.7 per cent of capacity) and 1,468,000 tons one year ago. Index of production was 109.8.

November 14

Δ The Aluminum Assn. reports that net shipments of aluminum sheet and plate in September, 1961, totaled 124,436,000 lb, compared with 130,547,000 lb in August, 1961, and 108,429,000 lb in September, 1960. Shipments of aluminum foil including foil in lamination (aluminum content only) in September, 1961, totaled 21,537,607 lb, compared with 23,365,359 lb in August, 1961, and 20,389,007 lb in September, 1960.

November 14

Δ The Commerce Dept. reported that the U. S. deficit in international payments in the third quarter widened to a seasonally adjusted annual rate of slightly more than $3,000,000,000 in the third quarter, compared with rates of $1,900,000,000 in the second quarter and $1,400,000,000 in the first quarter.

Δ Advancing prices in the New York stock exchange

increased the Dow-Jones average 3.60 points to 728.43, highest level in the compilation's 65-year history.

Δ The Bureau of Mines reports that consumption of scrap in the United States in September, 1961, totaled 4,981,000 gross tons, compared with 4,982,218 tons in August, 1961; consumption of pig iron in September, 1961, amounted to 5,451,000 gross tons, compared with 5,246,254 tons in August, 1961.

Δ The Bureau of the Census reports that production of titanium mill products in the U. S. in September, 1961, totaled 893,338 lb, compared with 960,647 lb in August, 1961, and 944,553 lb in September, 1960.

Δ The Bureau of the Census reports that shipments of commercial steel forgings for September, 1961, totaled 99,021 net tons, compared with 97,441 tons in August, 1961, and 93,931 tons in September, 1960.

November 15

Δ The Commerce Dept. reported that steel imports in September, 1961, totaled 269,000 tons, down 12 per cent from the August level, but 30 per cent over the September, 1960, level. U. S. exports of steel in September totaled 165,000 tons, an increase of 10 per cent over the August, 1961, volume, but 28 per cent below shipments in September, 1960. Imports of steel in the first nine months of 1961 totaled nearly 2,200,000 tons, compared with 2,800,000 tons in the same period of 1960. Steel exports in the first three quarters of 1961 totaled 1,400,000 tons, compared with 2,400,000 tons in the same period of 1960.

Δ The AISI reported that production of steel for ingots and castings in October, 1961, totaled 9,170,000 tons, up from 8,915,257 tons in September, 1961, and 6,868,380 tons in October, 1960.

Δ Northwestern Steel and Wire Co. reported for the quarter ending October 31, 1961 net sales totaling $22,052,314, net earnings of $1,394,763 or $0.56 per share compared with sales totaling $18,332,759, net income of $1,841,652 or $0.74 per share for the same period of 1960.

Δ Iron ore shipments down the Great Lakes by the U. S. and Canada in October, 1961 totaled 8,324,620 gross tons, compared with 7,013,603 tons in October, 1960. Shipments for the 1961 season to November 1 totaled 57,611,568 gross tons, compared with 67,694,037 tons in 1960.

November 18

Δ The AISI reports that production of steel for the week ending November 18, 1961, totaled 2,037,000 net tons (about 71.5 per cent of capacity) compared with 2,046,000 tons one week ago (71.8 per cent of capacity) and 1,470,000 tons one year ago. Index of production was 109.3.

November 20

Δ Government figures show that personal income in October, 1961, rose to a seasonally adjusted annual rate of $425,000,000,000, up $3,900,000,000 over the September, 1961 rate.

November 21

Δ The Bureau of the Census reported that net shipments of aluminum pig and ingot in September, 1961, totaled 127,591,000 lb, compared with 123,512,000 lb in August, 1961, and 105,565,000 lb in September, 1960; net shipments of aluminum mill products in September, 1961, totaled 286,864,000 lb, compared with 303,162,000 lb in August, 1961, and 253,216,000 lb in September, 1960. Net shipments of magnesium mill products in September, 1961, totaled 2,266,000 lb, compared with 2,320,000 lb in August, 1961, and 2,125,000 lb in September, 1960.

November 22

Δ The ARCI reported that deliveries of new freight cars in October, 1961, totaled 1907 compared with 2700 in September, 1961, and 4632 in October, 1960. Orders in October, 1961, totaled 2086 cars, compared with 3143 in September, 1961, and 5664 in October, 1960. Backlog of cars on order as of November 1, 1961, totaled 10,297 cars, compared with 10,133 on October 1, 1961 and 22,900 on November 1, 1960.

Δ The Aluminum Assn. reports that production of primary aluminum in October, 1961, totaled 167,295 tons, compared with 159,572 tons in September, 1961, and 167,015 tons in October, 1960.

November 25

Δ The AISI reports that production of steel for the week ending November 25, 1961, totaled 2,032,000 net tons (about 71.3 per cent of capacity) compared with 2,037,000 tons one week ago (71.5 per cent of capacity) and 1,367,000 tons one year ago. Index of production was 109.1.

November 27

Δ F. W. Dodge Corp. reported that total construction contracts in October, 1961, amounted to $3,290,716,000, compared with $3,319,145,000 in October, 1960. Index (1947 to 1949 = 100) in October, 1961, was 289, compared with 293 in August, 1961, and 294 in October, 1960.

November 28

Δ The National Machine Tool Builders Assn. reports net new orders of cutting and forming-type machine tools in October, 1961, amounted to $56,950,000, compared with $66,600,000 in September, 1961. Shipments in October, 1961, totaled $56,850,000, compared with $51,900,000 in September, 1961.

Δ The AISC reported that bookings of fabricated structural steel in October, 1961, totaled 303,208 tons, compared with 408,000 tons in September, 1961, and 245,799 tons in October, 1960. Shipments in October, 1961, totaled 354,480 tons, compared with 326,164 tons in September, 1961, and 352,779 tons in October, 1960. Backlog as of October 31, 1961, was 2,566,499 tons.

November 29

Δ The Dept. of Labor reported that its consumer price index rose to 128.4 per cent of the 1947–1949 average in October, 1961, compared to 128.3 per cent in September, 1961 and 127.3 per cent in October, 1960.

November 30

Δ The Dept. of Commerce reported that manufacturers' sales and new orders in October, 1961, totaled $32,700,000,000 seasonally adjusted, up one per cent over September, 1961, and 12 per cent over October, 1960.

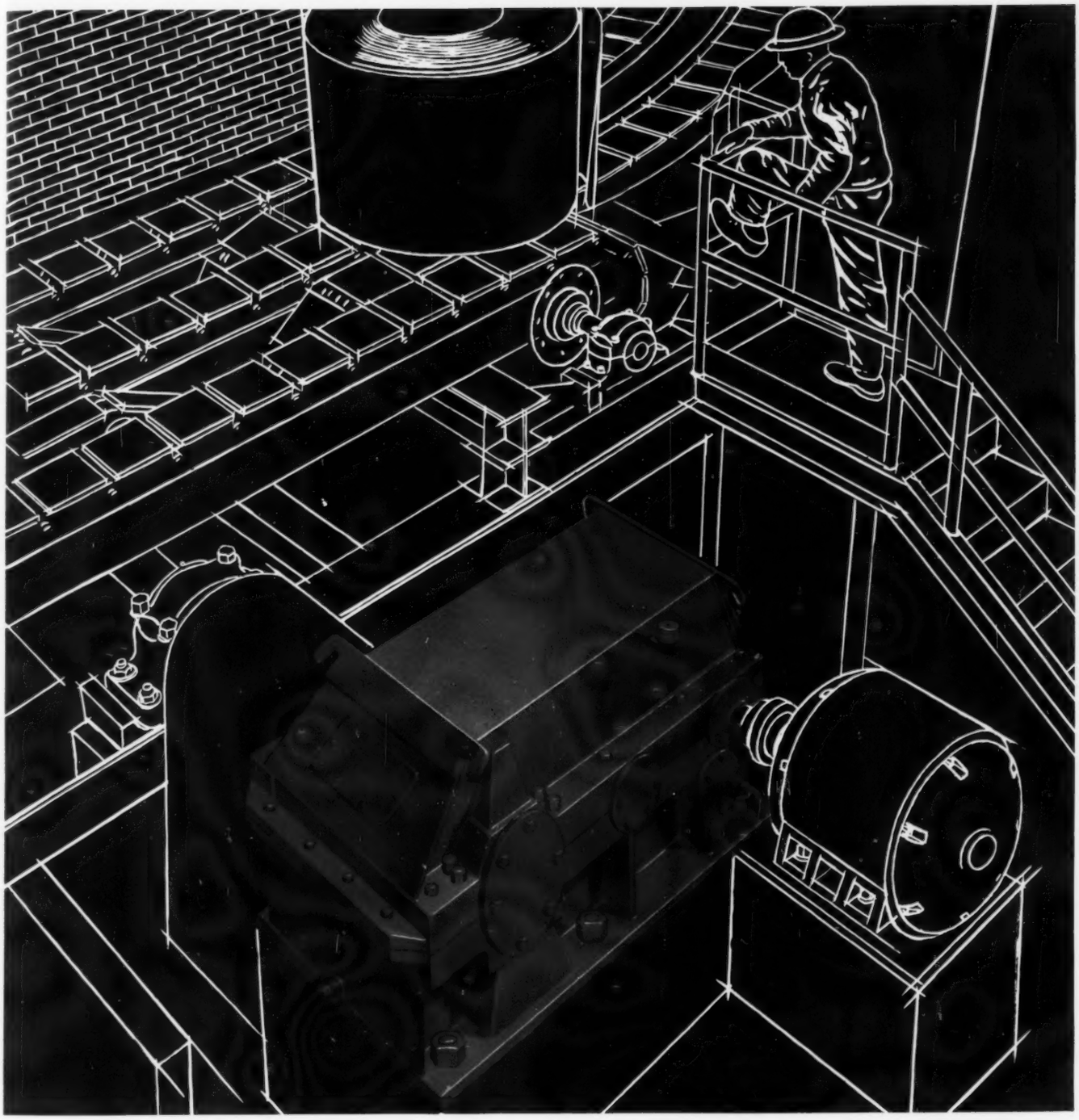
Δ Factory stocks on October 31, 1961, totaled nearly $54,800,000,000, up $300,000,000 over the September 30, 1961 level, after seasonal adjustment.

Δ Wheeling Steel Corp.'s first common dividend payment for 1962 will be 50¢, compared to the previous 75¢ quarterly dividends: 1961 earnings are expected to be below $2 a share compared with $3 dividend payout for the year.

November 31

Δ The Bureau of the Census reports that shipments of iron and steel castings in September, 1961, totaled 1,103,265 net tons, compared with 1,098,945 tons in August, 1961, and 1,067,843 tons in September, 1960.

Δ The Bureau of the Census reports that shipments of nonferrous castings in September, 1961, totaled 177,679,000 lb, compared with 186,803,000 lb in August, 1961.



LINK-BELT PARALLEL SHAFT MILL DRIVES WITH NEW WELDED STEEL HOUSINGS

shrug off shock loads

Mill engineered Link-Belt parallel shaft drives are built for continuous duty under the most grueling conditions. They are ideal for applications involving heavy shock loads and temporary overloads. The rugged welded steel housings withstand severe external abuse and keep parts accurately and permanently aligned.

Herringbone or double helical gears are arranged in a "balanced" design that provides high-hp, high-ratio reduction. Other features include: positive splash lubrication, high-capacity spherical roller bearings and unique grease-lubricated seals.

Link-Belt offers 57 sizes . . . shafts projecting at two, three or four locations. Single, double and triple-reduction types, capacities to 2800 hp, ratios to 292:1.

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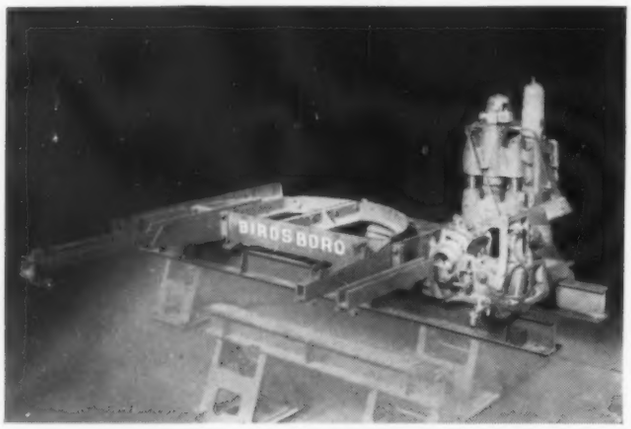
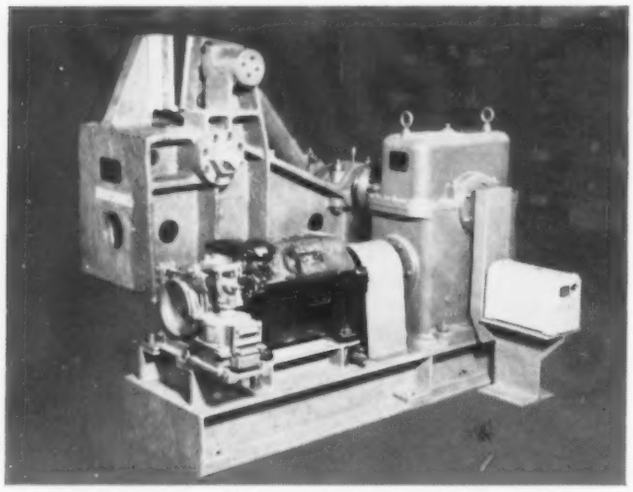


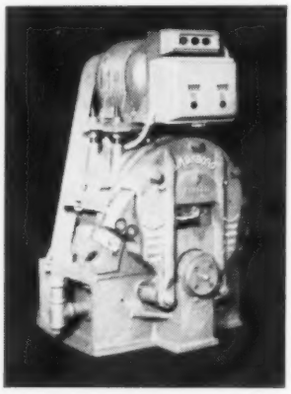
25 ton Hydraulic Plunger type Crop Shear cuts $1\frac{15}{16}$" x $2\frac{7}{16}$" stainless steel bars at six cuts per minute. A self-contained hydraulic system operates the ram. Shear is mounted on repeater base.

Hydraulic Alligator type Shear cropping bar at alloy rod mill roughing stand. Shear operates automatically when bar is inserted.

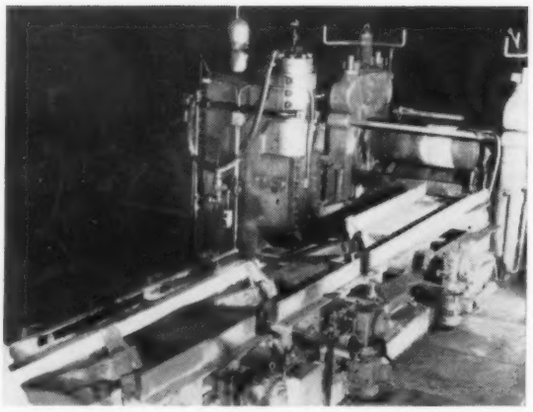


Vertical Crop Shear with direct mechanical drive crops strip and skelp before coiling.

Portable Crop Shear with electric motor drive and starter in a single compact unit. Can be quickly shifted by crane to any location.



Air-operated fingernail Crop Shear cuts $\frac{9}{32}$" x $\frac{3}{4}$" oval with curved end for easy entry into pass. The unit is automatically actuated when looper inserts bar.



36 ton Hydraulic Crop Shear—with air operated stop—crops front end of 3" x 3" hot billets. The entering bar actuates shear, while completion of cut lowers stop for bar to enter pass.

STATIONARY CROP SHEARS

designed and built by MM 8-61

BIRDSBORO CORPORATION BIRDSBORO, PENNSYLVANIA

STEEL MILL MACHINERY • HYDRAULIC PRESSES • CRUSHING MACHINERY • SPECIAL MACHINERY • ROLLS • ELECTRIC STEEL CASTINGS: Carbon, Low Alloy and STAINLESS STEEL

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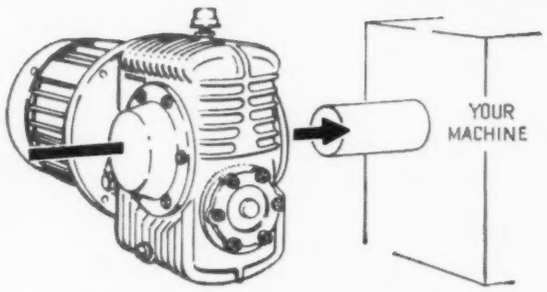
CONE-DRIVE GEARMOTORS for "PLUG-IN" POWER



Hollow-Shaft Speed Reducer-Motor forms complete power transmission package . . .

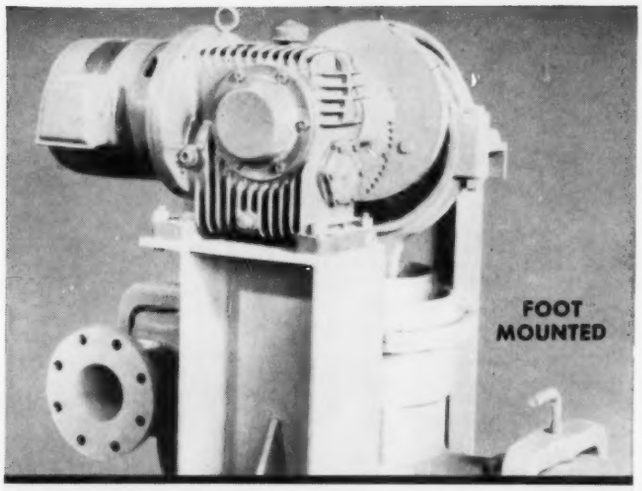
With the compact, right-angle Cone-Drive gearmotor the machine designer can make use of an integral drive package of nearly any required speed and horsepower. Twenty-seven standard output speeds from 7.3 to 525 RPM (with 1750 RPM motor) are available in models from ¼ to 40 horsepower. Gearmotors can be specified with hollow shaft for mounting in any position, ready to "plug-in". You can use this integrated power package to provide a simple, clean installation on your machine . . . no pulleys, belts, sheaves, bed plates, couplings, etc.

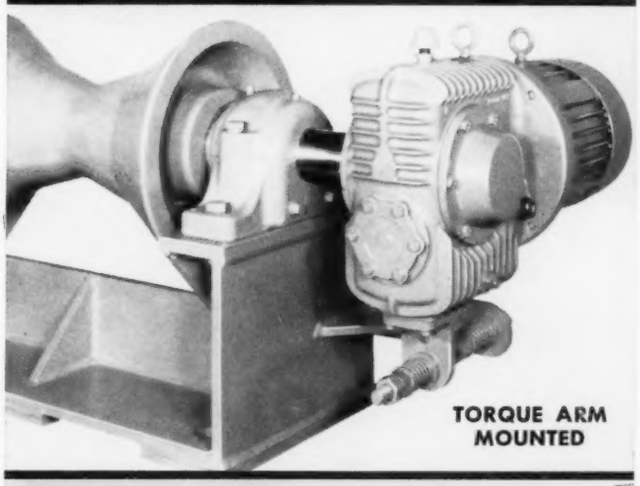
Electric motors are standard "D" flange type with slight shaft modification for driving helical primary reduction gears. Secondary reduction stage is a standard Cone-Drive double-enveloping worm gearset with maximum tooth engagement for greater load carrying capacity in smaller space.

Cone-Drive gearmotors are available for all AGMA service ratings. Call your Cone-Drive representative today or write for catalog #58 for complete specifications.

CONE-DRIVE GEARS
DIVISION MICHIGAN TOOL COMPANY
7171 E. McNichols Road Detroit 12, Michigan Telephone: TWinbrook 1-3111

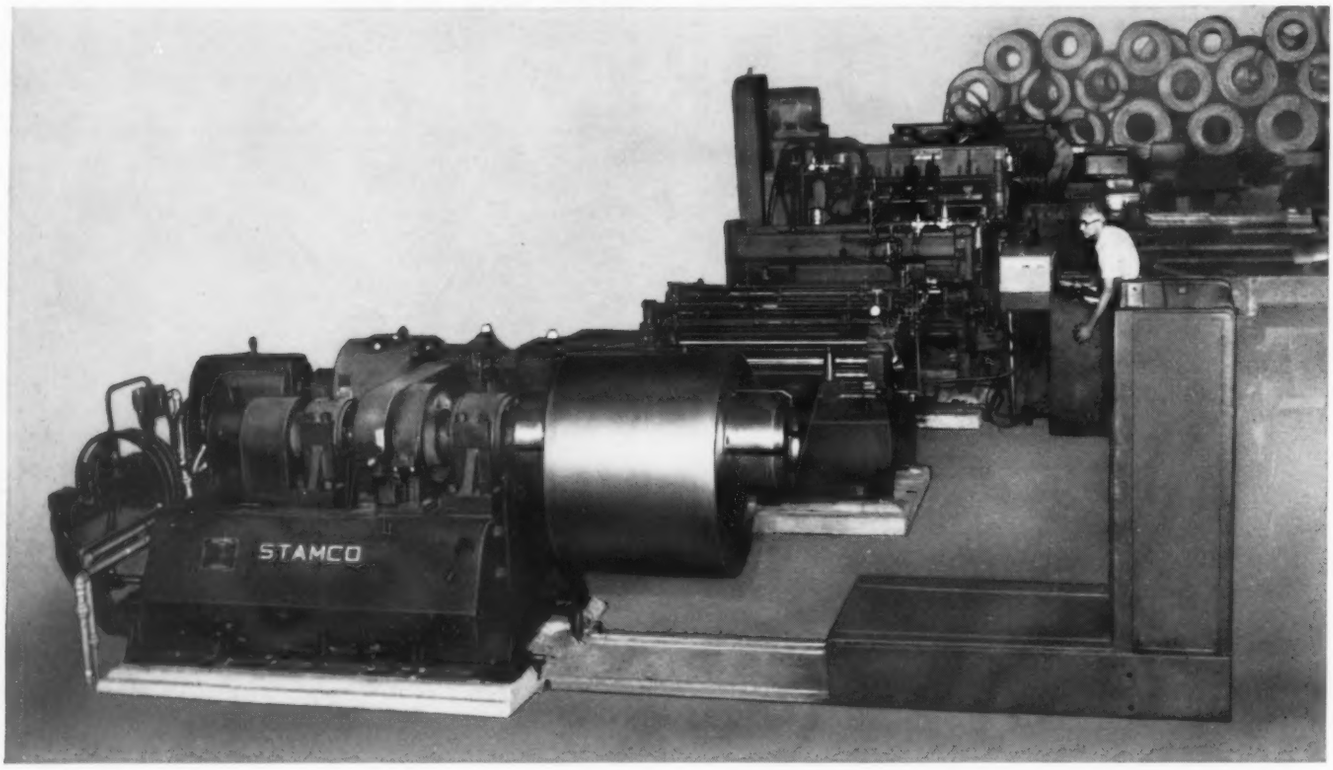
DOUBLE-ENVELOPING WORM GEARSETS
DOUBLE-ENVELOPING WORM GEAR SPEED REDUCERS
DOUBLE REDUCTION WORM GEAR SPEED REDUCERS
DOUBLE-ENVELOPING RIGHT ANGLE GEARMOTORS





Stamco equipment

handles coils up to 72 inches wide . . . reduces operating costs



Designed and built for greater capacities, this new Stamco shear line will accommodate stock up to 14 gauge, in widths to 72 inches. It handles coils weighing a maximum of 20,000 pounds. Accuracy can be held to plus or minus 1/32 inch. Lengths can be cut from 14 inches minimum to any maximum length.

Stamco, Inc., New Bremen, Ohio, U.S.A.

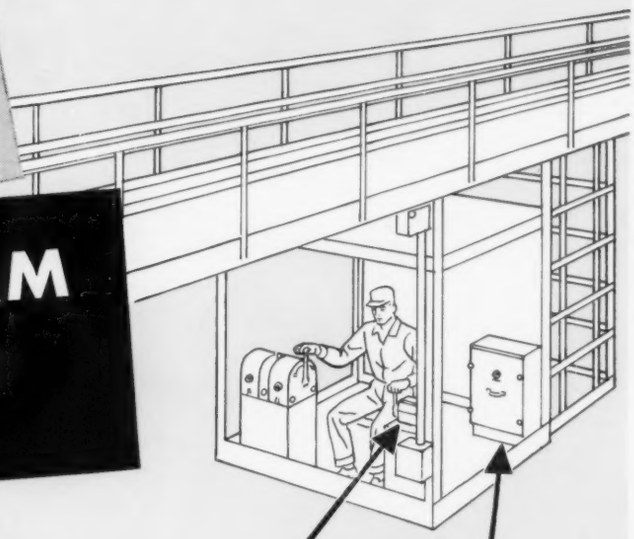
Slitting and Coiling Lines • Cut-to-Length Lines • Flying Shear Lines • Power Squaring Shears • Continuous Process Lines
Ferrous and Non-ferrous Mill Equipment

District Offices Stamco Sales, Inc.

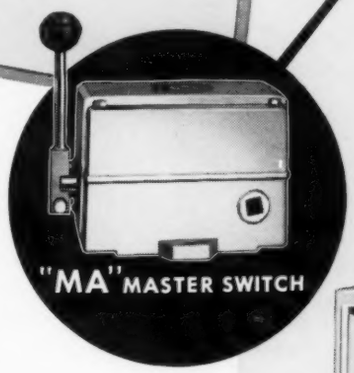
R. P. Popp, 18450 Livernois, Detroit 21, Michigan
R. P. Popp, 101 Investment Building, Pittsburgh 22, Pa.
I. W. Spraitzar, 159 Main Street, Chatham, New Jersey
W. E. Heineman, 122 West Burlington Ave., LaGrange, Illinois
W. H. Millan, 11955 Shaker Boulevard, Cleveland 20, Ohio

Better than Manual Control for So Many Reasons!

NEW LOW COST EC&M MAGNETIC CONTROL FOR DC CRANES



Now, on any DC application up to 55 HP, 230 volts, you can have the advantage of full *magnetic* control where manual control formerly was specified purely on the basis of price. At comparable cost, EC&M's new *Type PT* Magnetic Control gives you—



"MA" MASTER SWITCH

Compactness—fits easily in crane cabs, on crane walkways and wherever space is limited.

3-point or 4-point Speed Control

Reduced Motor Wear through automatic acceleration. Acceleration relays adjustable from a minimum of 0.2 second up, per step.

Space Saving—front connection permits mounting against wall.

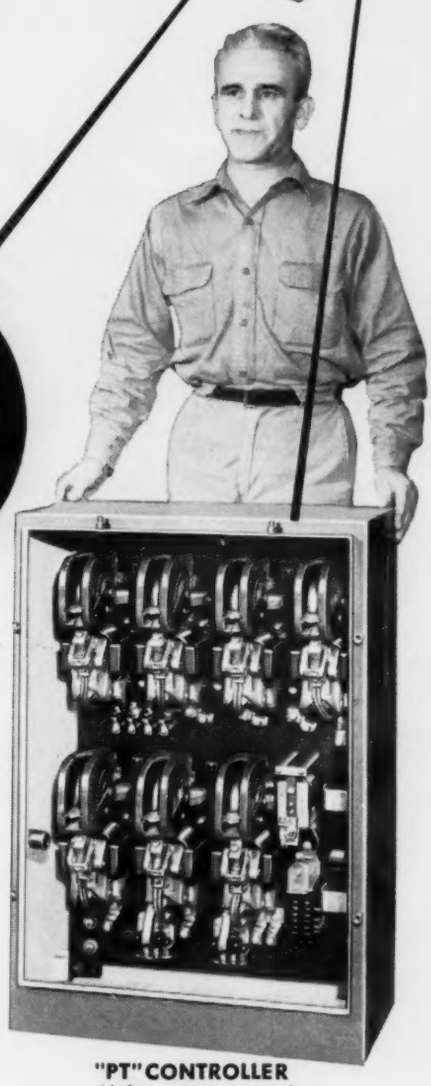
Hi-Speed Lowering with 4-point hoist control.

Fewer Spares—no manual control parts to stock.

Choice of Mounting Arrangements—MA Master Switch can be ganged with other masters or self-contained on top of the PT Controller.

Standardized Overload Protection is available. Separate panel for protection of 1 to 4 motors is smaller, simpler than protective panels used with manual controllers.

Write FOR BULLETIN 6131



"PT" CONTROLLER
with front cover removed

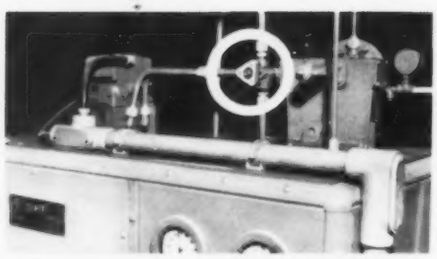
Available for Hoist, Bridge and Trolley motions on cab or floor-operated cranes

SQUARE D COMPANY

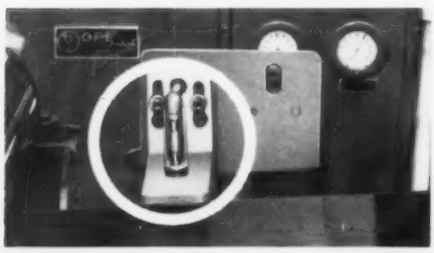
EC&M DIVISION • CLEVELAND 28, OHIO

wherever electricity is distributed and controlled

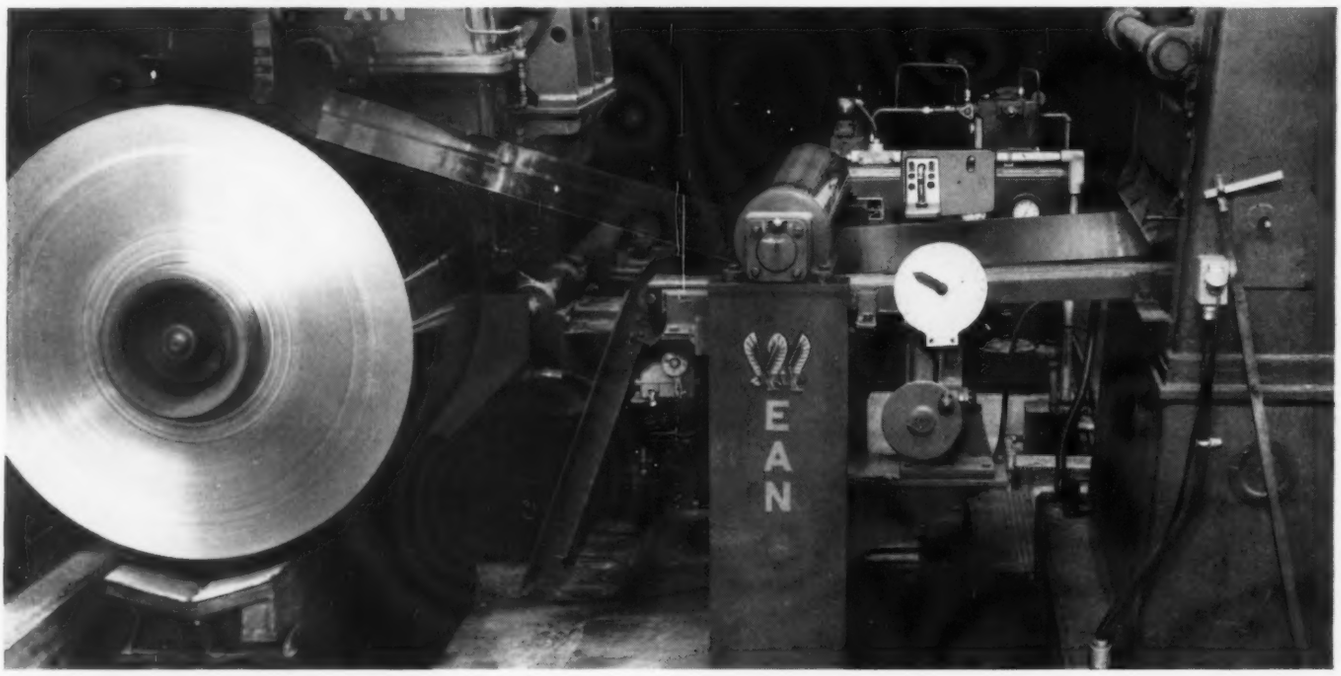
7418



GPE CONTROLS ADJUSTABLE-GAIN BOOSTER — Even a slight error in strip position produces maximum corrective force with complete stability. A simple screwdriver adjustment matches the control system to your strip processing line. If it doesn't have this advanced feature, it's just not a modern strip guide!



NON-CONTACT, NON-CLOGGING SENSING HEAD — Nothing touches the gleaming surface of the strip but a breath of air! And only GPE Controls gives you precise, simple pneumatic sensing with patented non-clogging design. Maintains accuracy of control without excessive maintenance.



High-finish tinplate line at Granite City Steel uses GPE Controls Edge Guide for mirror-edge wind-up coil

This GPE Controls air-hydraulic strip guide – on the "B" Electrolytic Tin Line at Granite City Steel – is one of the four similar units now operating in this modern mill. And *three more* GPE Controls Strip Guiding Systems will soon be in operation.

Here at the wind-up, the line operates at about 1000 feet per minute. GPE Controls Strip Guide continuously positions the wind-up reel to produce a mirror-like metal edge on the wind-up coil. Tinplate quality is protected in handling and shipping because the coil edge is perfectly smooth!

Steelmakers and steel users alike have shown their preference for GPE Controls by making it the most widely used strip guide. For simplicity, for control accuracy, for construction that cuts maintenance to the bone—you can't beat GPE Controls!

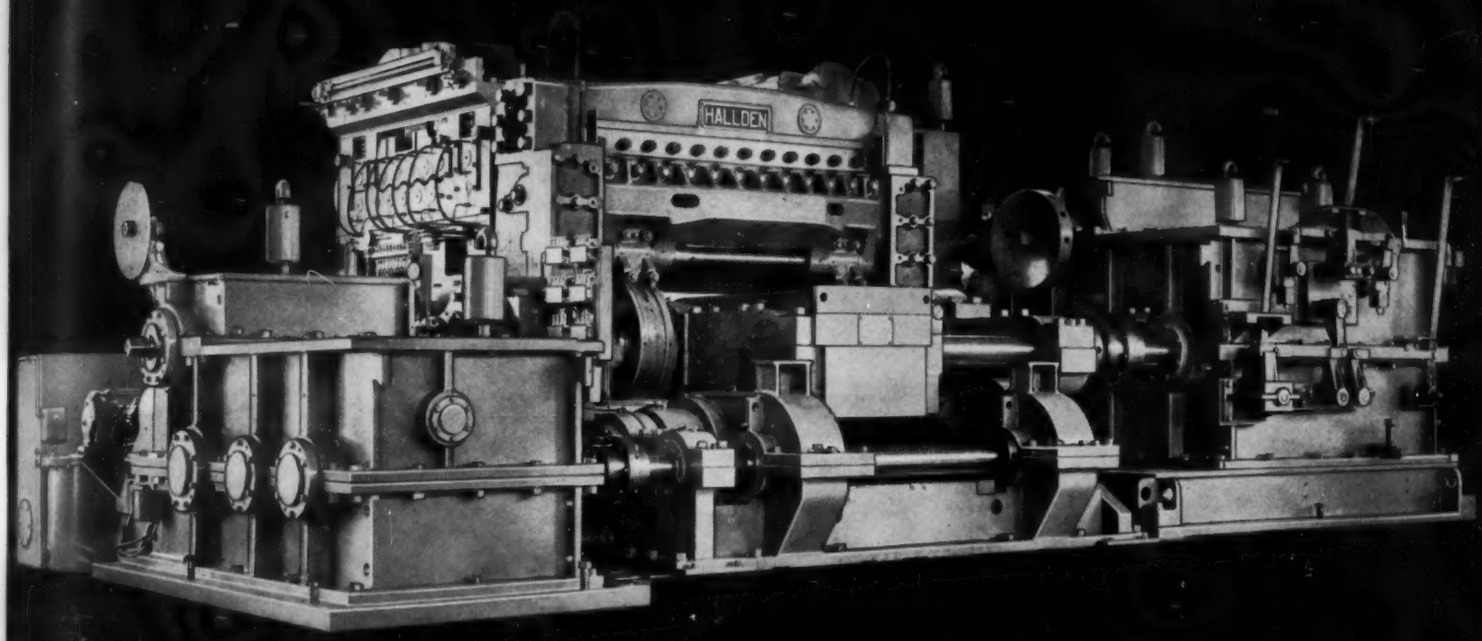
Write for informative Bulletin EG84

GPE Controls, Inc.

240 East Ontario Street • Chicago 11, Illinois

GPE Controls | GP

A Subsidiary of GENERAL PRECISION, Inc.



SYNCHRONIZED
GUILLOTINE FLYING SHEARS

Specified throughout the world for the most modern high speed processing lines

Hallden Flying Shears are built in a wide range of designs and sizes to meet any strip shearing requirement from tin plate to 5/8" plate. Length of cut ranges from 12 inches up to 48 feet. Synchronization adjustment "on the fly" available. These rugged units have been proven on steel, aluminum and brass strip in cut-up, galvanizing and special process lines for nearly 40 years. For all high production strip shearing consult Hallden, The Shearing Specialists.

HALLDEN

The world's leading machinery manufacturers rely on Hallden shears in their process lines

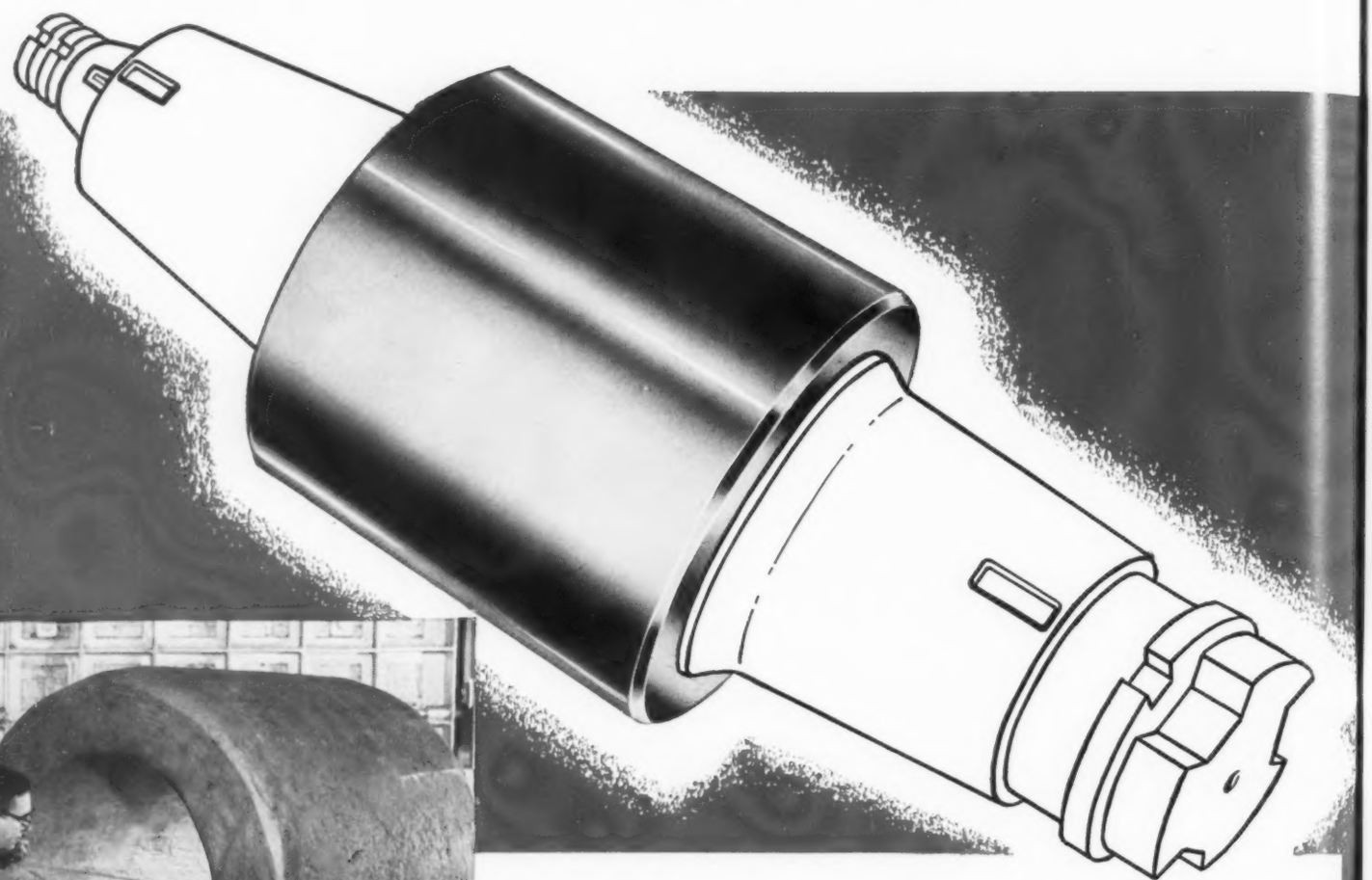
THE HALLDEN MACHINE COMPANY • THOMASTON, CONNECTICUT

Associates: The W. H. A. Robertson & Co., Ltd., Bedford, England

Ohio

FORGED SLEEVES

of Vacuum poured Degassed Steel



Give Back-up Rolls new lease on tonnage life

Back-up Rolls are good for a whale of a lot of extra "mileage" when you "retread" with Ohio Steel's tough Forged Roll Body Sleeves of vacuum poured degassed steel. Ohio applies these accurately machined sleeves to either new or used forged steel or cast steel arbors for maximum tonnage life. Previously sleeved back-up rolls can also be machined down and re-sleeved at substantial savings.

For a complete back-up roll service to meet the most exacting specifications, rely on Ohio Steel—manufacturers of all types of iron, steel and forged steel rolls. Ask your Ohio roll sales engineer or write for details.

THE OHIO STEEL FOUNDRY COMPANY
LIMA, OHIO

OHIO IRON and STEEL ROLLS

Carbon Steel Rolls	Flintuff Rolls	Denso Iron Rolls
Ohioloy Rolls	Double-Pour Rolls	Nickel Grain Rolls
Ohioloy "K" Rolls	Chilled Iron Rolls	Special Iron Rolls
Nioloy Rolls	Forged Steel Rolls	

PLANTS AT LIMA AND SPRINGFIELD, OHIO. *Virtually at the center of the Steel Industry*

OR-52

Industry News...

PHOENIX TO ADD WIDE PLATE HEAT-TREAT LINE

△ Phoenix Steel Corp. will add a continuous wide plate heat-treating facility at Claymont, Del. The new equipment will be supplied by Drever Co., and will consist of plate heat-treating charging and cooling tables, a plate heat-treating furnace, a pressure plate quench and a side transfer car. There will be also, a multi-purpose plate heat-treating furnace with its charging table. In conjunction with the furnace equipment, there will be a leveler with approach tables, a 500,000-gal reservoir to supply water to the pressure quench and a mill transfer car.

The plate heat-treating line will have a 1750-F furnace capable of handling carbon and alloy steel plates in various thicknesses, widths and lengths up to a maximum size of 156 in. wide, 2 in. thick and 45 ft-0 in. long. The furnace is long enough (inside dimensions 174 in. wide by 100 ft-0 in. long) to handle two 45-ft long plates at a time. Maximum furnace temperature will be 1750 F with a minimum operating temperature of 750 F. Minimum plate thickness will be $^{3}/_{16}$ in. The furnace will be a six zone roller hearth with all rolls driven and fully reversible, capable of oscillating operation, or continuous operation in either direction. The oscillating operation will be divided in two sections. At each end of this furnace 100-ft tables will be located which, because of the reversible operation of the furnace, will be used either for charging or cooling. Maximum production of normalized plate from this line is to be 56,000 lb per hour.

Following the furnace will be a 100-ton pressure quench that, by means of platens, keeps the plate flat during quenching. Quench water is delivered to the plate at the rate of 24,000 gpm through nearly 35,000 spray holes.

The quench is also used to quench plates from the 2100-F multi-purpose furnace. This furnace handles alloy or stainless steel plates in various dimensions up to a maximum of 156 in. wide, 2 in. thick and 45 ft-0 in. long. The furnace will be a three zone roller hearth with all rolls driven, fully reversible and designed for oscillating operation. Nominal production for annealing stainless steel plate is 23,400 lb per hour.

The actual products handled by both furnaces will range from $^{3}/_{16}$ in. up to 2 in. in thickness in full width material and in even thicker sections in narrower widths of plate.

Control of the heat-treating furnaces, the quench and all auxiliary equipment will be centralized in a control room which will also house the instrumentation.

This combination of plate furnace, multi-purpose furnace and pressure quench will provide Phoenix Steel with a versatile, flexible plate heat-treating facility. The company's product line will be increased to include normalized carbon and alloy steel plate, quenched and tempered construction grade alloy steel plate and stainless steel plate. The installation is expected to be put in operation in midsummer 1962.

MULTI-PURPOSE UNLOADER OPERATING AT HOUSTON

Installed on a 1000-ft long dock, this new ship and barge unloader is now in operation at the Houston, Texas, works of Sheffield Steel Division, Armco Steel Corp., after surviving the 100-mile an hr winds of Hurricane Carla. Ore is unloaded either into a belt conveyor, one of two hopper chutes for loading into rail cars, or an attached stacker belt discharging into a stockpile behind the dock. Machine was designed and built by Dravo Corp. The unloader is designed to handle either iron ore arriving by ship or coal arriving by barge. An 11-ton capacity bucket removes ore from the holds of ocean-going carriers at a free-digging rate of 1000 tons an hr.

ATLAS AWARDED INDIA KNOW-HOW CONTRACT

△ Atlas Steels Limited has been awarded a contract to supply know-how and training services to India's

Hindustan Steel Limited. Hindustan Steel will soon break ground for the construction of an $80,000,000 steel mill at Durgapur, about 100 miles from Calcutta, for the production of carbon and alloy tool steels, machinery steels, stainless steels and special purpose steels.

Under the terms of the contract, Atlas will make available to the Indian company the know-how required to produce quality special steels and in addition will set up training programs in Canada for groups of Indian technicians which, over the period of the contract, will total about 100. A number of Atlas technicians will be sent to Hindustan Steel's new mill once it is in operation to provide assistance in production techniques.

The new mill was originally scheduled to go into production in 1965 but steps are being taken to bring the completion date forward.

Initial output will be about 80,000 ingot tons with rapid expansion to 160,000 tons and provisions for an ultimate output of 300,000 tons. Engineering of the new mill is being handled by an Indian firm of consultants.

INITIAL NEW LACKAWANNA PRECIPITATORS READY

△ The first three open hearth dust precipitators of Bethlehem Steel Co.'s Lackawanna, N. Y., plant are ready for service. The oxygen furnaces affected are those in No. 2 open hearth shop. In addition, four precipitators are nearing completion in No. 3 open hearth shop.

The seven open hearth precipitators are a major phase of the plant's program of seeking maximum cleanliness of waste gases.

In all, this atmosphere improvement program has been under way for about 12 years. Precipitators have been installed at the new 45 x 90-in. slabbing mill and other plant operations. Improvements have also been made in the mixing of gases for reheating furnaces to eliminate smoke.

A considerable amount of time was required to squeeze the big precipitator equipment in the already crowded quarters around the two open hearth shops. At No. 2 open hearth, for example, the precipitators were built—in skyscraper fashion—right over a building which could not be moved.

The construction work has taken about a year to complete.

AIR PRODUCTS DEDICATES NEW OXYGEN FACILITY

△ Another large oxygen, nitrogen producing facility was dedicated and placed on-stream by Air Products and Chemicals, Inc. Located in Cleveland, Ohio, the new facility will produce approximately 600 tons per day of liquid and gaseous oxygen, nitrogen, argon and neon.

Built at a cost of $10,000,000, this new plant also serves as the headquarters of the company's Cleveland district sales office. In addition to the production of liquid and gaseous oxygen, nitrogen, argon and neon, the plant supplies acetylene, hydrogen, helium, medical gases and a complete line of welding and medical equipment to users in the midwestern area.

Jones & Laughlin Steel Corp. will

New Hawk 401 Utiliscope

An Unprecedented Closed Circuit

Impressed by the potential value of closed circuit television but *depressed* by reports of high initial cost, expensive maintenance, constant requirement for difficult adjustments, and general unreliability? Then listen . . . to an unprecedented proposition from the world's oldest manufacturer of industrial closed circuit television: Indoor or outdoors, in any kind of weather with practically any degree of illumination, Diamond Electronics' all new Hawk 401 Utiliscope is *guaranteed on a money-back basis* to provide a sharp, clear picture of just about anything . . . perimeter barriers, gates, transfer points, loading docks, construction areas, vehicular movement, rooftops, hazardous areas . . . all from one safe, comfortable and convenient location. The Hawk requires no special housing, no special power supply, no special adjustments for changing light and weather conditions. Just plug it into an ordinary 110 V outlet and forget about it.

See for yourself. Call, write or wire and we'll arrange a demonstration within the week.

Diamond Electronics

Diamond Power Specialty Corporation • Lancaster, Ohio

receive the major portion of the plant's gaseous output through direct pipeline to supply the oxygen needs of its two new basic oxygen steelmaking furnaces. These furnaces will use about 1800 cu ft of high-purity oxygen for each ton of steel produced.

LICENSING AGREEMENT ANNOUNCED BY MORGAN

△ The Morgan Engineering Co. has concluded a licensing agreement with Pintsch Bamag, AG, of Cologne, West Germany, to manufacture for sale in the United States and Latin America, basic oxygen converters, parts, accessories and related equipment for steelmaking plants.

Morgan has further diversified its extensive line by the addition of the converters.

The first installation in the United States by Pintsch Bamag is at The Colorado Fuel & Iron Corp.'s Pueblo, Colo., Plant, which includes two 100-ton basic oxygen converters now in operation.

permits...

Proposition In Television...

MESTA SLABBING MILL SCHEDULED FOR USINOR

△ Mesta Machine Co. is furnishing a 45 in. x 120-in. slabbing mill and related equipment to Union Siderurgique du Nord de la France which is to be installed at Dunkirk, France.

This mill is designed to roll slabs 3 in. to 12 in. thick, 40 in. to 65 in. wide, and 75 in. to 118 in. long from ingots weighing up to 25 tons. When the installation is complete it will include a roller table-type ingot buggy, ingot receiving table, transfer table, scale table, a 25-ton load cell ingot scale with automatic printer, mill tables, runout tables and a 25-ton slab shear.

Each of the special alloy cast-steel rolls for this mill will be driven by 5000-hp motors. The mill will be equipped with a double manipulator, hydraulic roll balance and roll changing rig. Mesta is supplying a recirculating oil lubricating system and centralized grease system for the installation.

The slabs from this new mill will be rolled into steel products for the shipbuilding industry in the Dunkirk locality.

CF&I PLANT ADDS NEW WIRE PRODUCTION UNIT

△ The Colorado Fuel and Iron Corp.'s South San Francisco plant has installed a unique new unit, the first of its kind in the West, for producing oil-tempered spring wire.

The unit is unique in that it can oil temper a range of wire sizes that normally have required the construction of two or more separate units, and therefore it represents a significant advance metallurgically.

By providing the needed variable accuracies in atmosphere control, furnace temperature and pull-through speed, the installation has increased CF&I's production flexibility.

Coils of selected high carbon steel wire are placed on 12 free spinning pay-off reels, then drawn through the atmosphere controlled furnace where the wire is hardened and

ROCKWELL-REPUBLIC

V-5 gauges combine small size with big-gauge readability

TRY THIS "CUTOUT TEST"

For a true demonstration of the readability of Rockwell-Republic V-5 gauges, cut out the actual-size photo at the right. Mount it on any wall or panel board. Step back and see how easily the scale can be read, even from 10 or 12 feet away!

BIG-GAUGE ACCURACY, TOO

Compact V-5 gauges are equipped with electric receivers or full sized diaphragms, bellows, and helixes for maximum accuracy and sensitivity. Yet these Rockwell-Republic gauges require one-fourth the panel space needed for standard gauges.

GROUP MOUNTING INCREASES VERSATILITY

As many as eight gauges can be grouped in a single mounting case. Types can be mixed to meet individual panel requirements. Mounting is simple, too. Just a panel cutout is required in most cases.

There's a V-5 gauge for almost every process measurement. Mail the coupon today for the 12-page bulletin on these easy-to-read gauges, and for available literature on other Rockwell-Republic instruments, controls, and valves. RF-22

REPUBLIC INSTRUMENTS AND CONTROLS
more fine products by
ROCKWELL

Please send latest literature on the following:

☐ V-5 Gauges ☐ Process Transmitters ☐ Controllers
☐ Computing Relays ☐ Control Stations ☐ Recorders
☐ Flow Meters ☐ Drive Units ☐ Control Valves
☐ Desuperheating & Pressure Reducing Systems
☐ Electronic Control Systems ☐ Pneumatic Control Systems

Name _____ Title _____
Company _____
Address _____
City _____ Zone _____ State _____

Republic Flow Meters Co. *(Subsidiary of Rockwell Manufacturing Company)*
2240 Diversey Parkway, Chicago 47, Illinois

coated with a controllable iron oxide.

From the furnace the wire passes through an oil quench, which is a tempering medium which sets the hardening. The wire then enters a lead drawing furnace where its desired ductility is restored, passes through a water cooler and finally is run over sheaves partially placed in an oil bath which gives the wire a light oiling before it is coiled on the take-up block.

The 300 to 600-lb finished wire bundles are coiled on 72 in. maximum to 16-in. minimum blocks, depending upon the wire diameter.

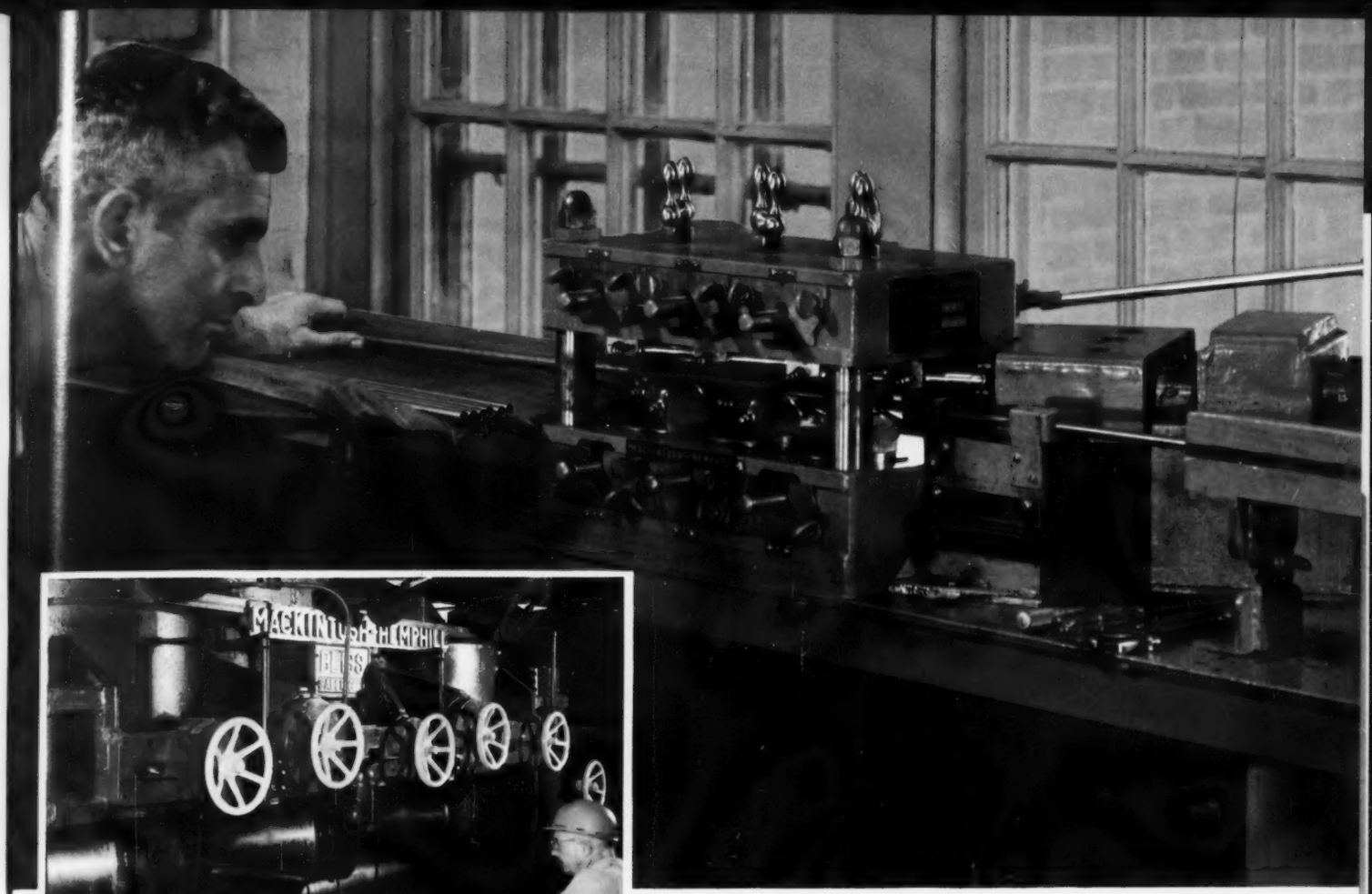
A radiant tube atmosphere controlled furnace provides the key to the unique operation. Designed so that both atmosphere ratio and temperature can be controlled, the furnace provides the correct hardening temperature and exact amount of iron oxide coating for a wide range of wire varying in size from $\frac{5}{8}$ in. thru 0.041 in. (19 gage) in diameter.

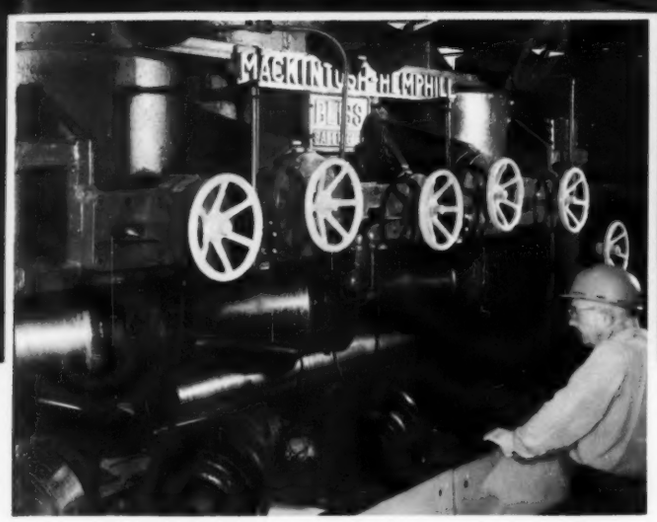
Nitrogen, the furnace's basic atmosphere, is supplied by a generator which manufactures and dries the nitrogen. The nitrogen ratio, which determines the amount of iron oxide coating the wire receives, and the temperature of the furnace are precisely controlled and varied to compensate for different wire sizes.

In addition, the speed of the wire as it passes through the various processes is controlled by spindles.

The correct hardening temperature and the precise amount of iron

Worker slides oil-tempered wire off a take-up spindle at unique new oil-tempering spring wire unit. Wire will next be removed by an electric hoist, and the spindle will be free to receive another finished roll.





JEWELERS' TUBING
OR 16-INCH PIPE

One pass... and it's straight and round as a gun barrel

The largest rotary tube straightener we make weighs more than 80 tons and straightens 16-inch pipe with ease; the rolls of the smallest model are only 3/4 of an inch in diameter and weigh 4 ounces apiece. Identical to the big one in everything but size, its three sets of top- and bottom-driven rolls straighten tubing with O.D.'s that must be measured with a micrometer . . . O.D.'s as small as .030-inch.

Mack-Hemp's line of fourteen straightener models covers every size of pipe and tubing between these two extremes, and is used with practically every metal and alloy . . . for such varied applications as refrigerator tubing, thermocouples, fuel elements, electrical conduit, heat exchangers, and even jewelry. No matter what the size, every Mack-Hemp straightener brings pipe and tube to perfect straightness and roundness in a single pass, at speeds that range to 800 feet per minute or more. Each works without guides, so there are no marks on the straightened tubing. And each is designed with an open, three-post construction that makes for easy maintenance and resetting of the rolls for various tube diameters.

NEW 24-PAGE TECHNICAL BULLETIN NOW AVAILABLE . . . tells how to solve straightening problems . . . how to adjust rolls and straighteners. Gives tips on rod straightening . . . light tempering . . . derodding of tubing. Cites nine different ferrous and non-ferrous case histories. Send for your copy today.

MACKINTOSH-HEMPHILL DIVISION · PITTSBURGH U.S.A.
BLISS

MACKINTOSH-HEMPHILL
Division of E. W. BLISS Company
901 Bingham Street, Pittsburgh 3, Pa.

oxide coating imparted to a wide range of wire sizes can be achieved with these variables. This variable nitrogen atmosphere replaces the use of additional units with lead baths for hardening the finer sizes of wire considered necessary to impart the correct amount of iron oxide coating to the wire.

SYNTRON DIVISION MOVES INTO NEW FACILITIES

△ Transfer for production equipment and personnel into the firm's new half-million dollar semiconductor plant has been completed by the Semiconductor Division of Syntron Co. Adjoining the company's headquarters plant and offices at Homer City, Pa., the new facility will be devoted exclusively to the production of silicon power rectifiers and assemblies.

The entire 16,000-sq-ft area of the modern plant is devoted to production facilities. Offices, laboratories and other supporting activities will remain in the adjacent headquarters building. The Syntron Semiconductor Division produces a complete line of selenium rectifiers and stacks, selenium cartridge rectifiers and silicon diodes and stacks.

Fast, economical, thoroughly proved in more than 50 plants . . . the McLanahan Scrap Bundler rolls the scrap into a compact ball, then ejects it. *Model 18* for a bundle 18" diameter x 18" long. *Model 24* for a 24" x 24" bundle. *Ask for Bulletin, Prices and a List of Users.*

McLANAHAN Corporation

HOLLIDAYSBURG, PENNSYLVANIA

Since 1835 . . . Manufacturers, Founders, Machinists

LOUISVILLE PLANT ADDS NEW BRIGHT ANNEAL LINE

△ New equipment, which greatly expands the potential markets for flat-rolled stainless steel, is being installed at the Louisville, Ohio, plant of Jones & Laughlin Steel Corp.'s Stainless and Strip Division, it was announced by R. H. Loutzenhiser, vice president—production. A new bright annealing line, which will process material up to 51 in. in width, will go into operation within six months, Mr. Loutzenhiser said.

Fabricators, utilizing the greater widths of bright annealed stainless, now will be able to explore new applications which require larger parts. The extra width of the material also is expected to attract new applications in the architectural field and in other industries where a potential reduction of production costs on fabricated products is possible.

Plans at the Louisville plant include the installation of pickling equipment, which will expand the range of finishes to the stainless sheets and coils available to customers.

J&L's new line will be built around a vertical-type annealing furnace. The new anneal line differs from conventional lines in that stainless steel enters and leaves the furnace without material alteration of the surface appearance. For example, a sheet of stainless with a bright rolled finish may be processed without the appearance of a gray nonreflecting finish. This development is possible due to the inert atmosphere within the furnace.

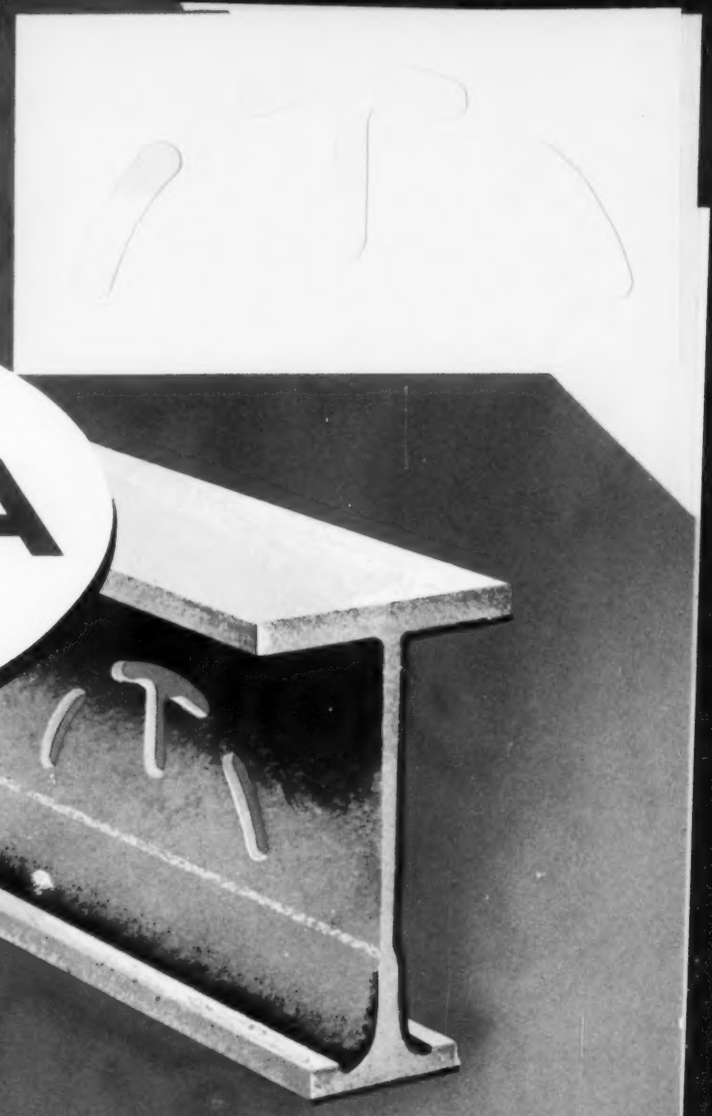
The Louisville plant, located near Canton, Ohio, is the division's principal facility for rolling stainless wide coils and sheets. Included in the equipment covering the 341,000-sq ft plant area are a 50-in. sendzimir precision rolling mill for 48-in. wide stainless sheets, annealing and pickling lines, slitting and cut-to-length lines, and polishing and grinding equipment.

Meetings

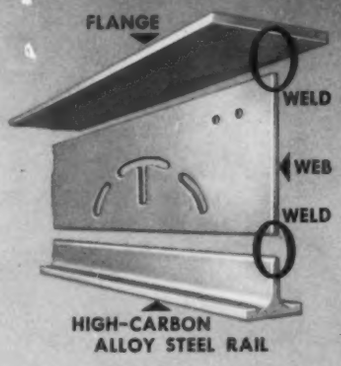
△ The 12th Annual Conference on Instrumentation in the Iron and Steel Industry will be held March 14–16 in Pittsburgh, Pa., at the Pick-Roosevelt Hotel.

Introducing a NEW IDEA in track design

TARCA TRACK



A TRULY SUPERIOR OVERHEAD MATERIALS HANDLING TRACK



Integrally Welded

Automatic welding machinery especially developed for Tarca Track fabrication assures reliable welds. Top flange, web, and high-carbon steel rail are joined by continuous welds to form a one-piece dependable unit.

Tarca Track—an outstanding, new Cleveland Tramrail development. Different from all other overhead materials handling tracks. Result of years of extensive research and testing.

Tarca Tracks are straight and accurate. Not subject to distortions and broad dimensional variations of ordinary tracks fabricated from standard mill beams.

Tarca wearing rails are hard. Made of high-carbon alloy steel integrally welded into a composite track section.

Tarca running treads are flat, raised, smooth. Enable easiest load movement —provide extra wear—prevent peening.

Tarca Tracks have great rigidity because all welds are continuous.

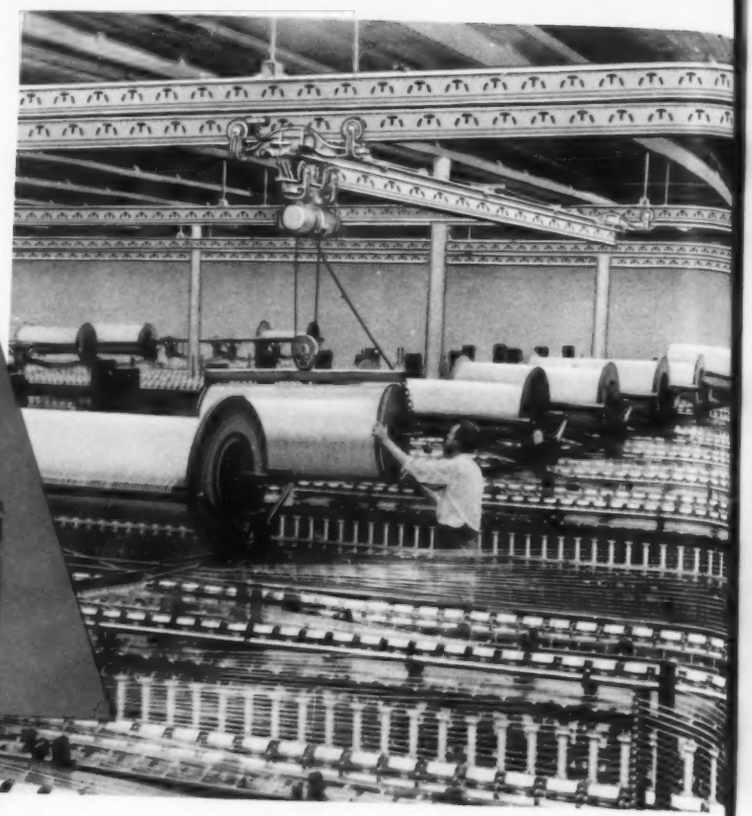
Tarca Tracks are faster, easier to erect. Greater track accuracy simplifies installation. New support fittings save erection time—facilitate track leveling —provide flexibility to relieve stresses from alignment variations.

Ten Standard Sizes—Tarca Tracks range from 8 to 20 inches in depth. Special sizes can be made to suit unusual requirements. Track parts easily proportioned to provide balanced design for any load condition.

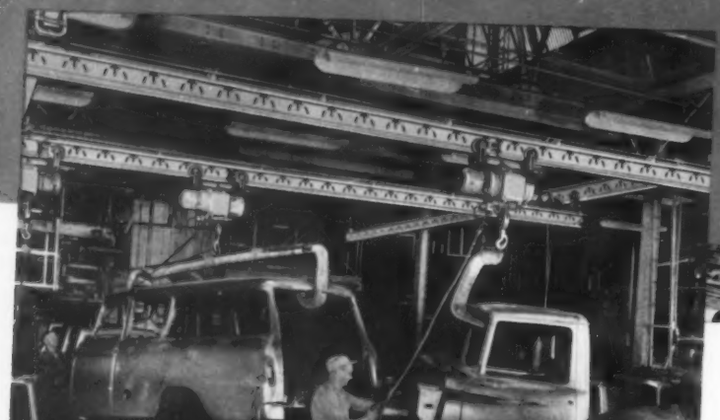
Ask for this helpful booklet—No. 2032

Covers all major features the buyer should know about overhead materials handling equipment. Has complete story on Tarca Track. Contains detailed equipment specifications and handy proposal evaluation form.

CLEVELAND TRAMRAIL DIVISION
THE CLEVELAND CRANE & ENGINEERING CO.
5899 EAST 284th STREET · WICKLIFFE, OHIO

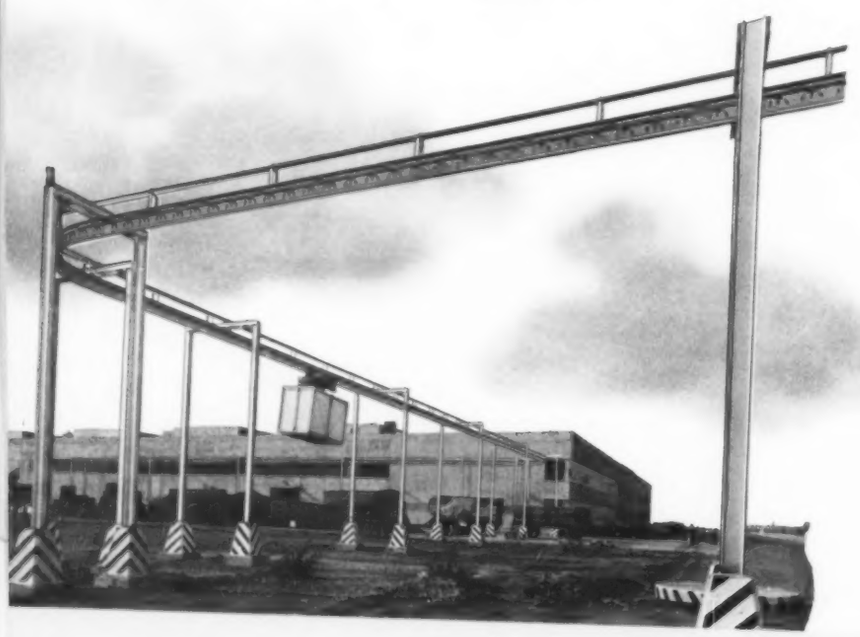


Trade—mark of durability and strength —punched into all Tarca Tracks.



Nearly all of the great American and Canadian automotive plants have installations of Cleveland Tramrail. Many include thousands of feet of track and hundreds of cranes.

Many hundreds of textile mills have depended for decades upon Cleveland Tramrail for a great part of their materials handling equipment. Illustrated is a Tarca Track crane system handling twister beams.

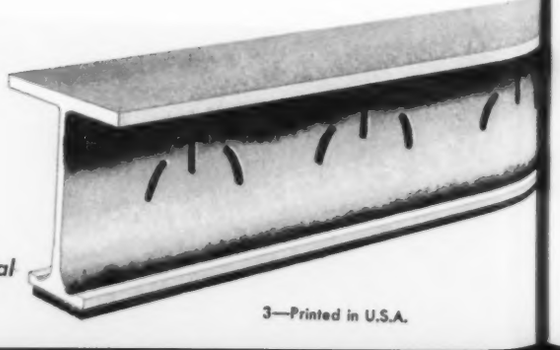


Cleveland Tramrail is a leader in automatic materials handling. A great variety of installations are in service. They operate between two or more points on the same or different elevations, or between buildings, as illustrated. One system serves 126 stations.

Your Cleveland Tramrail Sales Engineer is Qualified to give you the Complete Design and Application Story on This Revolutionary

NEW TARCA TRACK

Cleveland Tramrail is represented by competent, experienced engineers in all principal cities of the United States and Canada. Contact address on other side.



3—Printed in U.S.A.

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DECEMBER, 1961

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. . . any of the bulletins reviewed in the Publication Service of the IRON AND STEEL ENGINEER without obligation or cost. Simply circle the desired item numbers on one of the prepaid postal cards and mail. The requests will be forwarded to the manufacturers involved who will send the bulletins to you.

Note: Post cards expire three months after publication date.

(1) Self-Centering Rolls

The theory of operation of Lorig Aligner Type II Self-Centering Rolls is described and illustrated in an 11-page brochure produced by United States Steel Corp. Capable of positive centering and tracking of strip-like materials under all operating conditions, these rubber-covered rolls offer multiple benefits for many industries and processes. They are particularly beneficial when applied to tension bridles, to the handling of delicate strip, and when used as pinch rolls, idler rolls and pulleys in conveyors and other belted systems. Various applications are described wherein the self-centering rolls have greatly increased handling speeds for strip and web materials. This has resulted in greater product yield, higher product quality, longer roll life and other operating economies. (Brochure 78019-61)

(2) Air Pollution

Air Pollution Topics is a new quarterly bulletin published by Hemeon Associates, a firm of consultants specializing in air pollution problems. According to the editorial, the over-all problem is a relatively simple one when it is realized that the nuisance aspects of air pollution are of dominant importance. In addition to editorials, the bulletin will include case reports of investigations conducted by this organization. The bulletin is available without charge to interested parties upon request.

(3) Data Logger

A new bulletin released by The Bristol Co. is written to alert potential users to the economy and application flexibility of Data-Master automatic data loggers. Clear photographs supplement discussion of operating system installations in manufacturing, distribution and process industries. These loggers perform two basic functions: (1) accurate, systematic collection of process, test and other operating data and (2) presentation of this data in the most useful form for supervisory, process analysis, research and accounting purposes or for direct input into computers. (Bulletin D 401)

(4) Limiting Relay

A two-page bulletin describing the Rockwell-Republic VCRL pneumatic limiting relay is available from Republic Flow Meters Co. The pneumatic limiting relay monitors incoming signals against preset values or another signal and is ideal for such applications as fuel cutback and pressure override control. In addition to a description of the product and a discussion of its operation, the bulletin lists specifications and provides a schematic drawing of the operating cycle and an outline drawing of the product. (Bulletin 451.24)

(5) Gears and Reducers

A four-page, four-color brochure describes the engineering, testing and production facilities used to develop and produce the complete line of stock gears and speed reducers at The Ohio Gear Co. Pictured are such gear products as bevel and miter gears, spur gears, helical and worm gears, single and double reduction worm gear reducers, fin and fan-cooled Hi-Line reducers with such optional features as C-flange motor mounts with built-in flexible coupling, single and double helical gear reducers and bevel gear reducers. Full-color photographs reveal a few of the latest gear production machines in use at Ohio Gear Co., including a Reishauer gear grinder for spur and helical gears from 5 through 48 diametral pitch up to 9½ in. diameter; a Pfauter gear hobber for cutting 1½ diametral pitch and finer worm, spur and helical gears with up to 72 in. OD; an Ex-Cell-O precision thread grinder for worm and thread grinding up to 2½ diametral pitch and 48 in. long and an Ipsen atmospheric controlled heat-treating furnace.

(6) Safety Combination Starters

A descriptive bulletin shows features, components and dimensions for a new line of NEMA-12 safety combination starters manufactured by The Clark Controller Co. This bulletin describes the new sizes 0, 1 and 2 safety combination starters. This 2-page publication shows operation of the multiple-step enclosure door interlocking plus detailed illustrations with each component clearly labeled and described. Pictures also illustrate the simple method of removing the starter from the enclosure. Enclosure dimensions are given for starters both with and without a control transformer in the enclosure. Bulletin is punched for 3-hole binders for ease of filing or placing in a catalog. (Bulletin 6018-NEMA 12)

(7) Relays

A four-page publication describes General Electric Co.'s new CR120F transistorized sensitive relay. The publication explains the difference between transistorized relay and conventional magnetic relay as well as outlining where to use transistorized relay. Typical applications are listed along with specifications, typical connections, relay operations, ratings, typical dimensions and forms available. (Bulletin GPC-B49)

(8) Multi-Point Gages

A bulletin describing the complete line of multi-point gages for

indicating draft, pressure, differential and temperature is now available from Republic Flow Meters Co., subsidiary of Rockwell Manufacturing Co.

The four-page publication describes the gages, discusses product features in detail and illustrates them in cut-away photographs, lists standard scale ranges, provides diagrams and numerical data on mounting dimensions and includes diagrams and text on gage installation. (Bulletin 322.11)

(9) Ramming Mixes

A newly-revised handbook covering methods of installing periclase ramming mixes is now available from Kaiser Refractories Division, Kaiser Aluminum & Chemical Corp. Designed for use in connection with the installation of Permanente 165 and Permanente 84, the handbook covers proper methods of mixing and ramming the material and building the forms required for installation in open hearth furnaces. Included also is information on suggested heat-up schedules.

(10) Speed Reducers

A small shaft-mounted speed reducer, latest addition to the Torque-Arm line, is described in a four-page bulletin by Dodge Manufacturing Corp. Reported to be the smallest available reducer of its type, the TD025 is designed for shafts 1½ in. or less and for power requirements up to 1 hp at 90 rpm. Reduction ratio is 24.89:1, and output speeds range from 10 to 90 rpm. Reducer can also be flange mounted. A table of recommended V-belt drives permits easy selection of total speed ratios up to 175 to 1. Bulletin includes engineering drawings, dimensions, weights, prices and table of hp ratings for various classes of service. (Bulletin 602A)

(11) Lifting Magnets

Stearns Magnetic Products Division of Indiana General Corp. has released a bulletin showing an entirely new line of lifting magnets. This bulletin is complete with detailed cutaway views of the magnets, capacity and dimensional charts, and a helpful guide to the selection of the proper magnet. The bulletin lists over 50 styles and types of circular and rectangular lifting magnets with the circular magnets ranging in size from 20 to 80 in. in diameter and the rectangular magnets ranging from 9 x 24 in. to 26 x 80 in. (Bulletin 3022)

(12) Industrial Waste Treatment Guide

According to the new industrial waste treatment guide issued by B-I-F Industries, the growth of waste treatment plants has not kept pace with the growth of the pollution load. It has been estimated that 7000 new treatment plants will be required by 1970 and that expenditure for this problem will be nearly double what it was in 1960. The sixteen-page engineering data bulletin deals with the problems of waste treatment, classification of wastes and the methods of solving these problems. Four general classes of waste for food, mineral products, chemical processing and general industry, with their characteristics and strengths, are discussed. Equipment and processes used in unit treatment are detailed, including tanks, filters, aerators, chlorine gas feeders, vacuum filters, incinerators, sludge collecting and pumping equipment and many others. As a leading manufacturer of equipment and systems for positive control of materials flow, B-I-F is able to offer a comprehensive list of meters, dry, liquid or gas feeders, controls and accessories to handle the processes and functions of waste treatment. The engineering data lists special applications where B-I-F equipment is utilized in the operation and control of unit waste treatment processes. Classification, process and equipment tables, illustrations, schematics and a list of applicable B-I-F equipment are included in the engineering data. (Engineering Data Reference No. 3-SIC3900.21-1.)

(13) Solid Lubrication

The theory and use of solid lubricants are thoroughly discussed in an eight-page, four-color brochure published by The Alpha-Molykote Corp. Titled "Breaking Lubrication Barriers," the brochure discusses such barriers to effective lubrication as galling and seizing, extreme pressures, high friction, chemical reaction, temperature and extreme environments, and describes how solid lubricants can overcome them. The properties of molybdenum disulfide as a dry-film lubricant, including chemical stability, electrical and magnetic properties, thermal stability, and coefficients of friction are presented in detail. Actual applications describe how solid lubricants have solved difficult lubrication problems. The brochure is illustrated with photographs, charts, graphs and line drawings. (Bulletin 132)

(14) Crane Safety Limit Stops

The Euclid Electric & Mfg. Co. has issued a bulletin that describes their a-c and d-c crane power safety limit stops. They break the power circuit directly; provide d-c dynamic braking on d-c cranes; assure positive trip action; are weight tripped and weight reset and mount above the trolley floor. (Bulletin 2130)

(15) Speed Drives

The Louis Allis Co. has released a bulletin that describes the operation of Syncro-Range Select-A-Spede Drives. Ranging in size from 5-200 hp, these drives are suited for operation on multi-unit conveyors, textile or paper printing, etc. Referred to as a "packaged system," the Syncro-Range Select-A-Spede Drive consists of an adjustable frequency power supply, operating on 3-phase, 60-cycle power input powering a number of Syncro-Spede motors running in exact synchronism over a wide range of speed. Standard, squirrel-cage motors can be used where synchronous speed is not required. (Bulletin No. 112)

(16) Switchgears

Completely new-design 4.16 and 13.8-kv circuit breakers and switchgears, first in this rating developed specifically for stored-energy closing, are described in a bulletin published by the I-T-E Circuit Breaker Co. The three-color, 40-page bulletin provides drawings, sketches, photographs, specifications and charts as an aid to designers, architects and application engineers of industrial companies, utilities, contractors and consulting engineering firms. The bulletin furnishes comprehensive information on the new 4.16 and 13.8-kv equipment, including details on such major features as the stored-energy closing system, face-wound blowout coils and closed-door drawout. Also described are additional features of ease of maintenance, improved performance, smaller size and floor area, low center of gravity and superior compartment accessibility. Separate section describes

and illustrates conventional outdoor and standard enclosed full walk-in outdoor construction; and panel arrangements and full dimensions for standardized layouts. The bulletin also furnishes a simplified specification guide, including general specifications and a listing of individual components for each unit. Modern manufacturing methods, encompassing the full scope of extensive quality control procedures employed, are also described in a bulletin section. (Bulletin No. 2800-2B)

(17) Explosion-Proof Panelboards

A 28-page fully illustrated and detailed panelboard catalog bulletin, describing the many outstanding features in two all new series of explosion-proof panelboards, has been published by Appleton Electric Co. Each series incorporates design and engineering advances which give the user of hazardous location equipment the finest panelboards ever made available. Compact in design, light in weight, and easy to install and maintain, the EDP and ESP series represent an all new approach to explosion-proof panelboard construction. The EDP series features a unique exclusive PIVOT between junction and breaker housing. This is the key to compact size, Plug-In "E" Frame Breakers, easier, more convenient installation, quicker main and branch wiring and simplified maintenance. These panelboards are engineered to handle motor control, machinery, alarm, lighting and a wide range of circuits requiring breaker capacities of 15, 20 or 30 amp. (Bulletin 661)

(18) Strain Gages

A line of weldable strain gages is described in a product data sheet published by Electronics & Instrumentation Division of Baldwin-Lima-Hamilton Corp. The gages afford electrical stability and high linearity of response over a range of temperatures from cryogenic through 750 degrees F, and offer temperature compensation to plus or minus one part per million per degree F from 50 through 250 degrees. The data sheet gives illustrations and provides technical information on use of the gages for applications where standard types of strain gages cannot be used. Weldable gages are available in both bakelite and ceramic-bonded types, with a strain range of plus or minus ½ per cent (plus or minus 5000 microin. per in.). The data sheet also gives temperature coefficient curves, shows variation of gage factor with temperature, and provides design and application data along with ordering and price information. (Product Data Sheet 4324)

(19) Speed Reducers

Production of two completely new series of horizontal speed reducers is announced by The Falk Corp.: Parallel Shaft (Type Y) with ratios 1.84 through 292 to 1, and Right Angle (Type YB) with ratios 5.06 through 1207 to 1. Capacity ranges from 9000 to 1,570,000 lb-in. torque, in cataloged, standard units (higher in custom units) with 22 standard sizes for each type, permiting precise and economical selection. Gears are single helical (98½-per cent efficiency per gear mesh under full load) with precision cut extra-depth high pressure-angle tooth form for greater capacity and increased strength. Heavy-duty double ended shafts can be turned 180 degrees for double gear life, and have large diameters to accommodate maximum torque and overhung loads. Rugged housings have smooth flat surfaces for simple mounting of motor brackets, backstops, brakes and other modifications. Continuous positive lubrication is provided, with oil-tight, dust and waterproof-type shaft seals, and automotive-type dip stick for easy oil check.

(20) Power Supply Catalog

Just released by American Rectifier Corp. is a 44-page catalog covering their complete line of both standard and custom engineered power supplies, ranging in size from 50 w to 5000 kw. Over 3000 models are listed and described. This catalog was designed with a dual purpose, and that is, not only to allow the nontechnical man to find what he needs in a matter of seconds, but to give the engineering man technical data as well. There are many special features, such as: a glossary covering terms used most frequently in power supplies; a basic power supply and control feature evaluation chart which gives an evaluation as to what type of power supply is best for what features; an electroplating guide which gives the recommended rectifier power output for common plating applications. Information is included on rectifier circuits, suggested applications for various units, diagrams, and other information designed for both the technical and nontechnical man.

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IRON & STEEL ENGINEER
1010 EMPIRE BUILDING
PITTSBURGH 22, PA.

IRON & STEEL ENGINEER

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PUBLICATIONS CURRENTLY OFFERED by Iron and Steel Engineer Advertisers

ITEM	COMPANY	BULLETIN	DESCRIPTION
50	AJAX FLEXIBLE COUPLING CO., INC.	BULLETIN 70	Couplings
51	BELLOWS-VALVAIR	BULLETIN 603	Control valves
52	BLISS CO., E. W.	BULLETIN 40-B	Rolling mills
53	BUSSMANN MFG. DIV., McGRAW-EDISON CO.		Electrical power systems protection
54	CONE-DRIVE GEARS, DIV. MICHIGAN TOOL CO.	CATALOG 58	Gearmotors
55	DODGE MANUFACTURING CORP.		Couplings
56	DYNAMATIC DIV., EATON MFG. CO.		Eddy-current equipment
57	FALK CORP., THE	BULLETIN 4100	Couplings
58	FARREL-BIRMINGHAM CO., INC.	BULLETIN 122	Roll grinders
59	GPE CONTROLS, INC.	BULLETIN EG84	Strip guides
60	HOMESTEAD VALVE MFG. CO.	BOOK 39-3	Seal valves
61	LARCO, INC.	BOOKLET AC-573	Air rectifiers
62	LINK-BELT CO.	BOOK 2719	Shaft mill drives
63	McLANAHAN CORP.		Scrap bundlers
64	PLIBRICO CO.	LABORATORY REPORT 900-A	Refractory patching
65	ROCKBESTOS WIRE AND CABLE CO.		Wire and cable catalog
66	REPUBLIC FLOW METERS CO.		Gages
67	SPRAYING SYSTEMS CO.	CATALOG 24	Spray nozzles
68	SQUARE D CO., EC&M DIV.	BROCHURE 6414	Crane controls
69	SQUARE D CO., EC&M DIV.	BULLETIN 1312	Magnet cranes
70	TAYLOR CHAIN CO., INC., S. G.	BULLETIN 14-A	Sling chains and hooks
71	WAGNER ELECTRIC CORP.	BULLETIN IU-226	Hydraulic braking
72	WALDRON-HARTIG DIV., MIDLAND-ROSS CORP.	BULLETIN 2-1050	Couplings
73	WILSON ENGINEERING CO., INC., LEE	BULLETIN OC-960	Open coil gas alloying

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56-inch semi-continuous hot strip mill.

BLAW-KNOX HOT STRIP MILLS

Blaw-Knox designs and builds a full range of continuous, semi-continuous and single stand reversing hot strip mills. Other Blaw-Knox equipment for the metals industry includes complete rolling mill installations and auxiliary equipment for ferrous and non-ferrous metals. • Sheet and strip processing equipment. • Electrolytic tinning, annealing and galvanizing lines. • Seamless pipe and tube mills. • Draw benches, and cold draw equipment. • Blaw-Knox Medart cold finishing equipment. • Iron, alloy iron and steel rolls. • Carbon and alloy steel castings. • Fabricated steel plate or cast-weld design weldments. • Steel plant equipment. • Heat and corrosion resisting alloy castings. • Blaw-Knox Company, Foundry and Mill Machinery Group, Blaw-Knox Building, 300 Sixth Avenue, Pittsburgh 22, Pennsylvania.

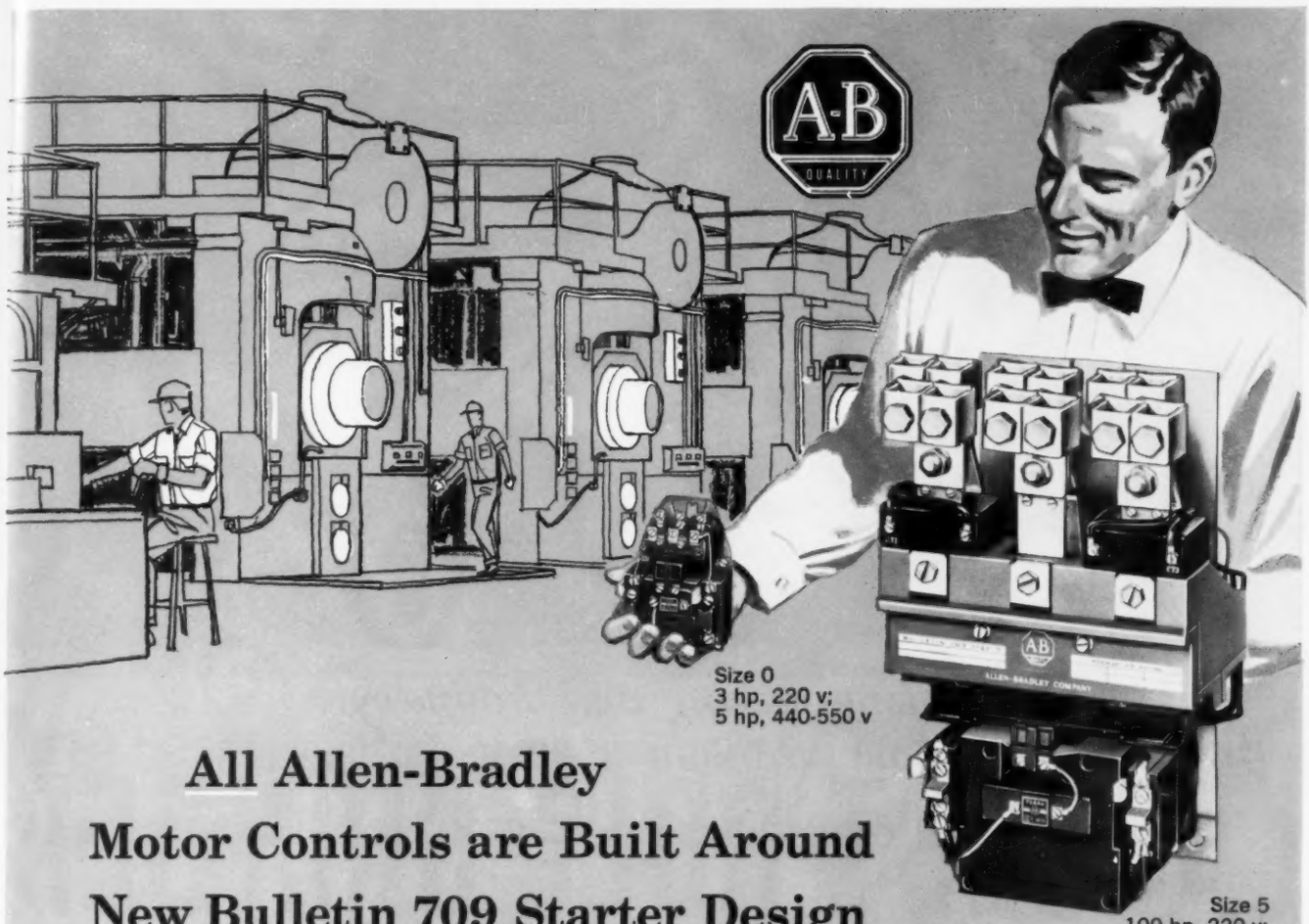
BLAW-KNOX

Blaw-Knox designs and manufactures for America's growth industries: METALS: Rolling Mills • Steel Processing Lines • Rolls • Castings • Open Hearth Specialties • PROCESSING: Process Design, Engineering and Plant Construction Services • Process Equipment and Pressure Piping • CONSTRUCTION: Concrete and Bituminous Paving Machines • Concrete Batching Plants and Forms • Gratings • AEROSPACE: Fixed and Steerable Antennas • Radio Telescopes • Towers and Special Structures • POWER: Power Plant Specialties and Valves

Buell SF Precipitators serve new basic oxygen plant at CF&I

As American steelmakers adopt basic oxygen processes, they face whole new problems of dust removal and recovery. Flue gases are loaded with sub-micron particles, which must be removed both for reasons of community relations and economics. ■ One of the newest basic oxygen steel units is at the Pueblo, Colorado plant of The Colorado Fuel & Iron Corporation. Here, CF&I relies on Buell SF Electric Precipitators to remove fine dusts from the oxygen unit's gases. With exclusive Spiralectrode® emitting electrodes, these collectors produce the highest rate of electron emission for peak recovery rates. This feature, combined with continuous-cycle mechanical rapping, results in uniform high efficiency performance. ■ In addition to the Precipitator, Buell also furnished the inlet and outlet flues, conveyors and pug mill. Buell Engineering Company, Inc., Dept. 60-L, 123 William Street, New York 38, N. Y. Member, Industrial Gas Cleaning Institute. ■ Northern Blower Div., Cleveland, Ohio. ■ VT Cyclones – SF Electric Precipitators – Venturi Scrubbers – Bag Collectors – Combination Systems – Classifiers – Fans

buell Norblo®



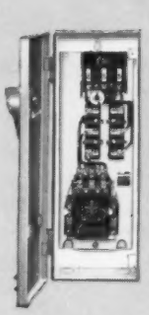
Size 0
3 hp, 220 v;
5 hp, 440-550 v

Size 5
100 hp, 220 v;
200 hp, 440-550 v

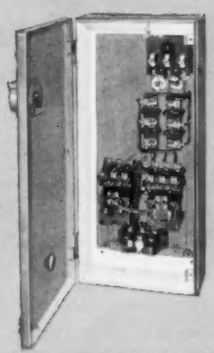
All Allen-Bradley Motor Controls are Built Around New Bulletin 709 Starter Design

Allen-Bradley's revolutionary across-the-line starter design brings new meaning to "reliability" and "operating life." Though the previous Bulletin 709 starters set the standards of performance on the basis of operating experience, they must bow low to the new Allen-Bradley Series K line. The simple, one-moving-part solenoid principle has been greatly improved to provide *many more millions* of trouble free operations. The new magnet is cushioned to reduce impact—this cuts wear. A "built-in" air gap eliminates magnetic sticking—permanently! With the new hot molded arc hood, continuous switching of full rated load is taken in stride . . . and there remains *extra capacity* to handle emergency conditions. The new cadmium oxide silver contacts are weld-resistant—they never need service attention. The enclosures, by internationally famous industrial designer Brooks Stevens, add a truly beautiful "businesslike" appearance to every installation. For complete information, please write today for Publication 6100: Allen-Bradley Co., 1343 South First Street, Milwaukee 4, Wisconsin.

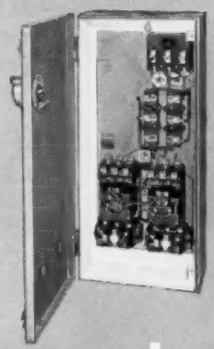
OTHER ALLEN-BRADLEY CONTROL USING NEW STARTER DESIGN



Bulletin 712
Combination Starter With Fusible Disconnect Switch in Nema Type 1 Enclosure



Bulletin 706
Reversing Combination Starter With Fusible Disconnect Switch in Nema Type 1 Enclosure

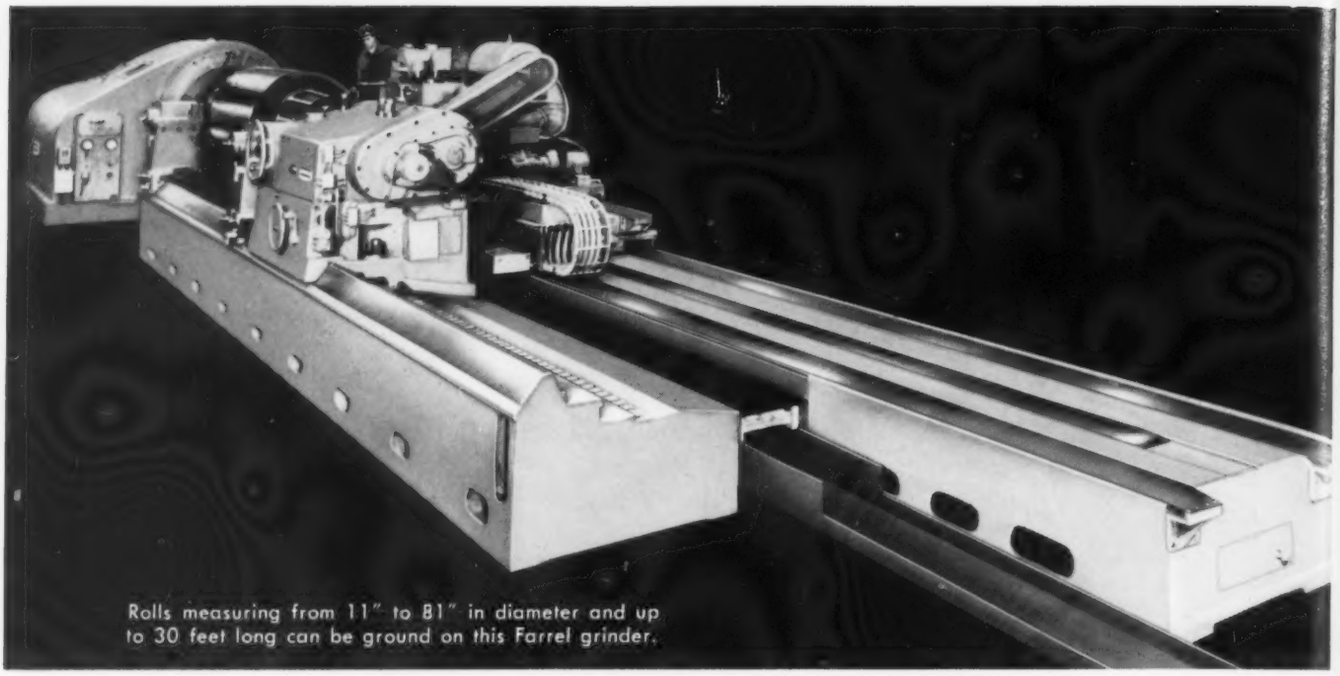


Bulletin 716
Two-Speed Combination Starter With Fusible Disconnect Switch in Nema Type 1 Enclosure

ALLEN-BRADLEY

Member of NEMA

Quality Motor Control



Rolls measuring from 11" to 81" in diameter and up to 30 feet long can be ground on this Farrel grinder.

At United Engineering and Foundry...

LARGEST ROLL GRINDER

ever installed in the western hemisphere

Built by Farrel to the requirements of United Engineering and Foundry Company, Pittsburgh, Pa., the machine above is now in service grinding mill rolls. It is the largest grinder ever built in this country and is capable of finishing the largest rolls used in the steel industry. It will handle rolls up to 81" diameter and will support 200 tons between centers.

As huge as it is, this is also one of the most accurate grinders ever built, thanks to Farrel's revolutionary new trunnion-tilt infeed system. And, because of the way the wheelhead is mounted on the upper part of a split carriage, it can be used with equal accuracy for grinding the roll face or taper journals. The upper carriage swivels and moves on its own ways in line with the angle of taper . . . can be operated in two directions for faster stock removal.

All controls are conveniently located on the operator's platform. From there, he can keep his eyes on the grinding wheel at all times.

This roll grinder is comprehensively covered in *new* 32-page bulletin 122.

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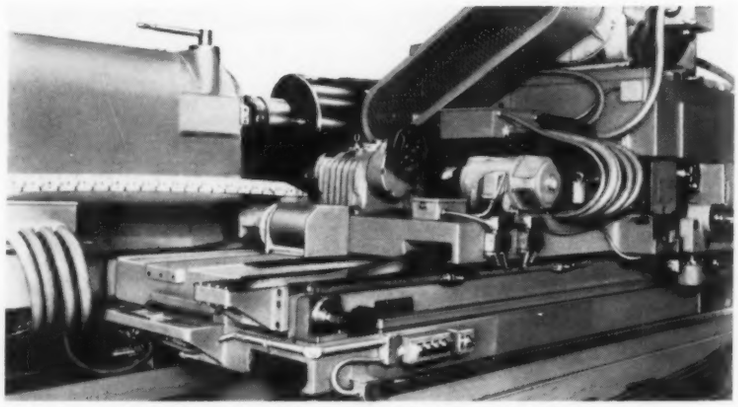

View of the special split carriage which permits grinding of taper journals using main wheelhead.

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"Electric arc melting gives us improved metallurgical quality at an economic advantage," says Birdsboro Corporation.

Steel castings provide a wide range of selective materials, both as to chemical analysis and mechanical properties, which are suitable for application in various service and environmental conditions. The recent selection by Birdsboro Corporation of two new electric arc furnaces to replace open hearths and to complement existing arc melting facilities has contributed markedly to diversification of their steel foundry operations to meet these requirements.

Demand has been matched with flexible melting capacity through installation of two Heroult Electric Arc Melting Furnaces:

Shell Size	Capacity	Melting Rate
8-foot	10-ton	2 tons per hour
13.5-foot	30-ton	7 tons per hour

These two furnaces increase total electric melting capacity to 300 tons per day.

Service to customers was the primary requisite in Birdsboro's selection of this equipment. In addition, sales possibilities have increased, quality of metal is superior, alloy recovery is higher, maintenance is reduced, and man-hours per ton is lower. Result—steady improvement of steel melting costs.

American Bridge constructs furnaces for all types of arc melting, in charge capacities to over 200 tons. You can select door-charge or swing roof top-charge types. Your crew can easily maintain a Heroult furnace.

If you're after melting flexibility, increased production, and lower costs, check American Bridge's complete design, construction and installation service.

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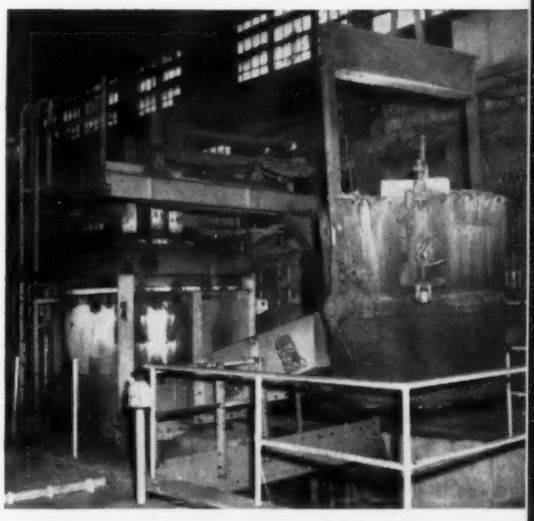

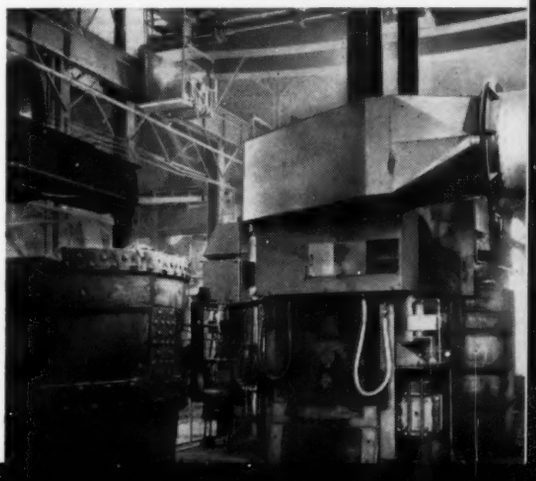

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Personnel News...

Clayton L. Squier has been appointed an assistant general manager of Bethlehem Steel Co.'s Lackawanna, N. Y., plant. He succeeds the late **Hal K. Wilson.** Mr. Squier has been assistant superintendent of the plant's Electrical Department for more than four years. He joined Bethlehem in 1935 as a member of its Loop course in management training for college graduates. Assigned to the Electrical Department, Mr. Squier became an assistant general foreman in 1938 and a foreman in 1940. In 1946 he was made assistant to superintendent. He was appointed assistant superintendent in 1957.

Robert A. Kraus has been named chairman of the Mechanical Maintenance Committee of Republic Steel Corp. He will continue his duties as superintendent of construction for the company's Warren steel plant. Mr. Kraus succeeds **R. F. Armitage,** recently named manager of the Warren district. Mr. Kraus joined Republic in 1939 as a student engineer at the Chicago plant. He subsequently served there as industrial engineer, lubrication engineer, general mechanical foreman and assistant superintendent of the Maintenance Department. He served as superintendent of the Maintenance Department at Chicago for two years prior to moving to Warren as superintendent of construction in 1959.

Robert A. Lubker has been appointed vice president, research and development, Alan Wood Steel Co. He worked for Westinghouse Electric Corp. in various metallurgical capacities, prior to joining The Armour Research Foundation in 1946. Mr. Lubker held the post of manager metals research at Armour for four years prior to coming with Alan Wood in 1958 as director of research and development.

Edward E. McGinley has been appointed manager of operations for all plants of the Phoenix Steel Corp. Mr. McGinley formerly was assistant general superintendent of the United States Steel Corp.'s Edgar Thomson Works. Mr. McGinley began his career with U. S. Steel in 1936 as an open hearth metallurgical observer in the Youngstown district. He later became, in turn, chief metallurgist for that district; divisional superintendent of steel production of the Youngstown district; and then divisional superintendent, Homestead works. In 1955, he was promoted to assistant general superintendent.

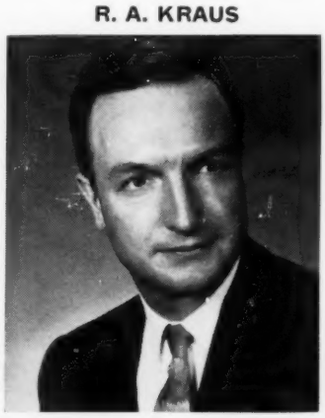
C. L. McGranahan, a pioneer in the strip rolling field, has retired from his position as technical counselor for La Societe Lorraine de Laminage Continu (SOLLAC) in France, where he has been for the past eleven years. He plans to locate in Pittsburgh in the near future and do consulting work. He was president of the Association of Iron & Steel Engineers in 1944.

G. T. Avery has retired as chairman of the board, Acme Steel Co., and **F. M. Gillies** has retired as senior consultant. Both had remained with the company beyond their normal retirement ages. Mr. Avery joined Acme in 1920. Before his election as president of the company in 1957, he occupied a number of positions in operations, including that of vice president—production. He was elected chairman of the board in 1960. The position of chairman of the board will remain vacant with the duties assumed by **G. F. Griffiths,** president and chief executive officer of the company. **F. M. Gillies** joined Acme in 1950 as executive vice president, following 30 years of service with United States Steel Corp. and Inland Steel Co. He was elected president of Acme in 1953 and chairman of the board in 1957. He has served as senior consultant since 1960.

L. D. Bowman was elected to the position of chairman of the board, Vanadium-Alloys Steel Co. At the same time **Dr. George A. Roberts** was named president and chief executive officer. They will fill the posts vacated by the death of **James P. Gill,** former head of the firm. **Dr. John C. Hamaker, Jr.,** was named to succeed Dr. Roberts as vice president—technology. Mr. Bowman,

C. L. SQUIER

R. A. KRAUS

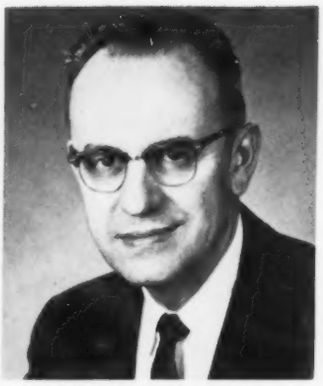


R. A. LUBKER

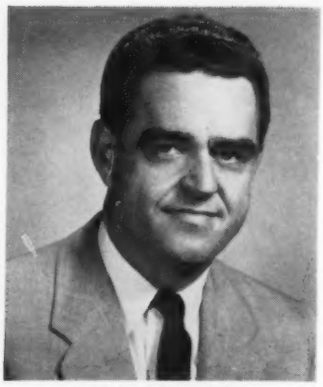
E. E. McGINLEY

K. R. DANIEL

W. C. MEYER



W. W. SCHEEL



J. W. COLLIER

who first joined Vanadium-Alloys in 1917 as a chemist, has been vice president of production since 1945. He served as plant metallurgist from 1920 to 1928, when he became works manager. In 1955, he was elected to the board of directors. Dr. Roberts has been associated with Vanadium-Alloys for 21 years. He began his service as a research metallurgist and in 1945 was named chief metallurgist. In 1953, he assumed the post of vice president—technology.

Dr. Hamaker joined the company in 1953 and was advanced to manager of the Research Department two years later. He was appointed director of research and metallurgical engineering in 1959. He has worked for the International Nickel Co., Rotary Electric Steel Co., Foundry Services, Inc., and the General Iron Works Division of Stearns-Roger Manufacturing Co.

Kenneth R. Daniel was elected executive vice president of the American Cast Iron Pipe Co. He was formerly vice president in charge of engineering and purchases. Mr. Daniel joined the company in 1936 and was employed in the Melting Department, Research Department, Fittings Foundry and Engineering Department. In 1948 he was promoted to chief engineer, and was elected vice president, engineering, in 1955. In 1958, he was named vice president—engineering and purchases.

W. C. Meyer has been appointed assistant to the vice president with Crucible Steel Co. of America. He will direct purchasing and traffic functions for the company. Mr. Meyer was formerly employed with Westinghouse Electric Corp. where he served in various purchasing capacities since 1941.

Wilbert W. Scheel has been named assistant superintendent of Republic Steel Corp.'s South Division in Canton, Ohio. He will be in charge of vacuum melting and its related operations in the South Division. He succeeds **Charles E. Fiala,** who died September 24. Mr. Scheel joined Republic as a laboratory metallurgist in 1940. He was appointed field metallurgist in 1946, and plant metallurgist for the South Division in 1954. He was named assistant to the plant superintendent in August this year.

Joseph W. Collier was named manager of production for Latrobe Steel Co. He had been chief industrial engineer at the plant.

A. R. Rios has been appointed vice president of Airco Co. International, a division of Air Reduction Co., Inc. Mr. Rios joined the Cuban subsidiaries of Air Reduction in 1922. From 1950 until 1960, he served as president of both Compañia Cubana De Products Del Aire and Compañia Cubana De Oxigeno. Since 1960, Mr. Rios has served as a staff member of Air Reduction Co., Inc.

L. A. (Bud) Myhre, Western Gear Corp. vice president, has been appointed manager of the company's Heavy Products Division, and will direct the shift of operations from Seattle to Everett, Wash. For the past 13 years Mr. Myhre has worked in an executive capacity at Western Gear plants in Southern California and Texas.

John J. McCarthy has been appointed assistant superintendent of the Masonry Department at Kaiser Steel Corp.'s Fontana plant. Mr. McCarthy joined Kaiser Steel in 1956 as foreman assistant in masonry. He advanced to practice assistant, shift foreman (labor) shift foreman (masonry) and in January, 1961, was named practice man, the position he held to his present appointment. Previously he was employed by Inland Steel Co., 1953–1956, where he was a central provider in production control. Prior to that he was employed at The Youngstown Sheet & Tube Co.'s Indiana Harbor works in the Coke and By-Products Department.

Charles A. Taylor has been named manager of the southeast region of The Electric Storage Battery Co.'s Exide Industrial Marketing Division, succeeding **J. A. Klingensmith** who retired November 30. A former Washington district manager with Edison Industries, Mr. Taylor has been manager of Exide's Washington district since the consolidation of the Exide and Edison Industries' sales forces last year. Mr. Klingensmith's retirement culminates a 33-year sales career with The Electric Storage Battery Co. Previous to his appointment as manager of the southeast region in 1959, he was manager of Exide's Washington district for 18 years.

C. L. Kerr has been appointed chief sales design engineer of Amsler Morton Co., a division of Textron, Inc. Mr. Kerr was previously with Selas Corp. of America and Salem-Brosius Co.

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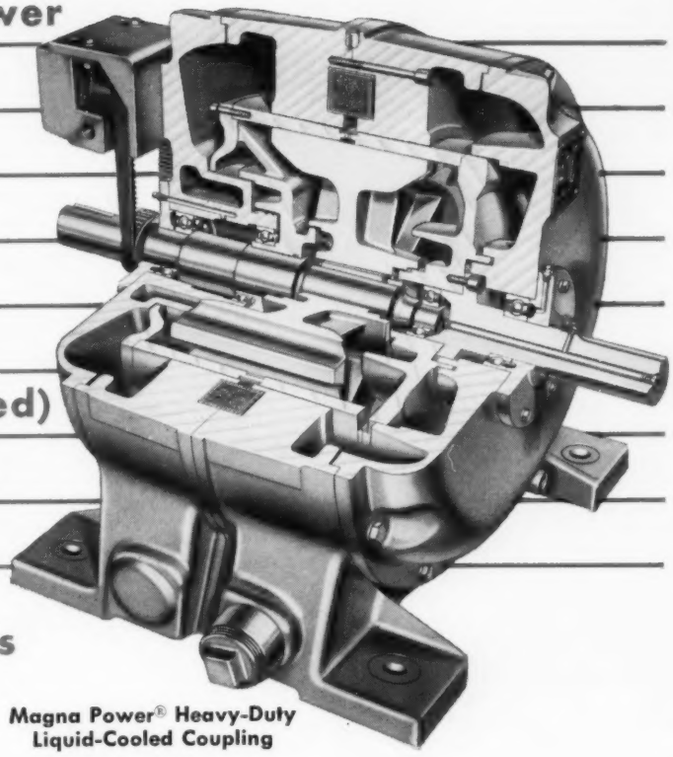

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G. C. BROOKE

R. W. FRANK

P. B. WISHART

H. P. RASSBACH

G. Clymer Brooke has been elected chairman of the board of directors and **Robert W. Frank,** president of Birdsboro Corp. Mr. Brooke is former president and Mr. Frank, who is also elected to the board, is former vice president. Mr. Brooke became president of Birdsboro in 1954. He joined the company in 1931, becoming assistant to the vice president in 1937, assistant secretary in 1941, and assistant to the president in 1944. He was named vice president in 1945 and executive vice president in 1953. Mr. Frank was named vice president of Birdsboro in 1957. He came to the company from Blaw-Knox Co. where he was president and general manager of the Lewis Foundry and Machine Division, and vice president and a director of the parent company. Prior to his presidency of the Lewis Division, he was assistant to the president. His earlier career included various positions at the Duquesne Works of U. S. Steel Corp. He was superintendent of the blooming and billet mills there from 1940 to 1945.

Paul B. Wishart, president of Minneapolis-Honeywell Regulator Co. since 1953, has been elected chairman of the board and chief executive officer, succeeding **Harold W. Sweatt,** who has been named chairman of the finance committee. **James H. Binger,** formerly vice president and director, was elected to succeed Mr. Wishart as president. At the same time, the company's directors created a third executive vice presidency and elected **Stephen F. Keating,** also a vice president and member of the board, to the new post.

Herman P. Rassbach has been appointed to the newly-created post of general manager—sales development and metallurgical service, Union Carbide Metals Co., Division of Union Carbide Corp. Mr. Rassbach, who has been in Cleveland as manager—metallurgical service since 1957, joined the company in 1950 as a development engineer. He has also held posts as metallurgical engineer, assistant development manager, and manager—Electric Furnace Department.

Stuart F. Joynt, Jr., has been appointed assistant chief metallurgist for the Buffalo district plant of Republic Steel Corp. He succeeds **J. M. Engel,** recently named chief metallurgist for the district. Mr. Joynt was employed as a metallurgical observer at the Buffalo plant in 1949. He was named metallographer in 1950 and was appointed research metallurgist in 1952. Since 1959 he has been field metallurgist and acting laboratory director at the Buffalo plant.

Benjamin P. Colosky, formerly staff sales manager, has been appointed general sales manager, Corhart Refractories Co. Mr. Colosky joined the company in 1957 as a development engineer in charge of market and product development. He later served as manager of sales technical services and was named staff sales manager in February, 1961.

Wainwright Holt, Jr., has been appointed to the new post of manager, compressor sales of Allis-Chalmers Manufacturing Co.'s Industries Group. Mr. Holt was a sales representative in the company's New York district office for seven years prior to 1958 when he became sales manager of centrifugal and axial compressors.

William A. Morton, chairman of the executive committee and director of Loftus Engineering Corp., retired recently after 50 years in glass and steel plant engineering.

William C. Zehnpfennig has been appointed manager of industrial control systems field engineering by Thompson Ramo Wooldridge, Dage Division. Before joining TRW in Michigan City, Ind., he was a private consulting engineer, had been senior project engineer for Bailey Meter Co. and a project engineer for Bendix Products Division.

Stanley W. Ewing, Jr., was appointed assistant manager steel sales of the Pittsburgh office, Climax Molybdenum Co., a division of American Metal Climax, Inc. Mr. Ewing comes to Climax from Tennessee Products and Chemical Co. where he was engaged in alloy steel sales in the company's Pittsburgh office. He had previously been employed in alloy steel sales by Pittsburgh Metallurgical Co., and in the sales department of General Electric Co.

Paul H. Magnus, II was elected president and **Donald H. Ambrose,** executive vice president, Rosedale Foundry and Machine Co. **David C. Chaplin,** former president, becomes chairman of the board and treasurer. Mr. Magnus most recently served as executive vice president and has held key positions in the company since 1949. Mr. Ambrose, former vice president, joined Rosedale in 1948 as metallurgist. He previously

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● Coils come down the line from the slitter into this big, rugged Signode M30. At the push of a button, inch-and-a-quarter strapping is applied through the eye in seconds—tensioned, sealed, and cut-off. The seal is on the *inside* of the coil. Another control rotates the coil for the next strap. Any number of straps can be applied. Finally, the machine ejects the strapped coil. The M30 handles coils up to 72 inches outside diameter, from 4 inches to 24 inches in width.

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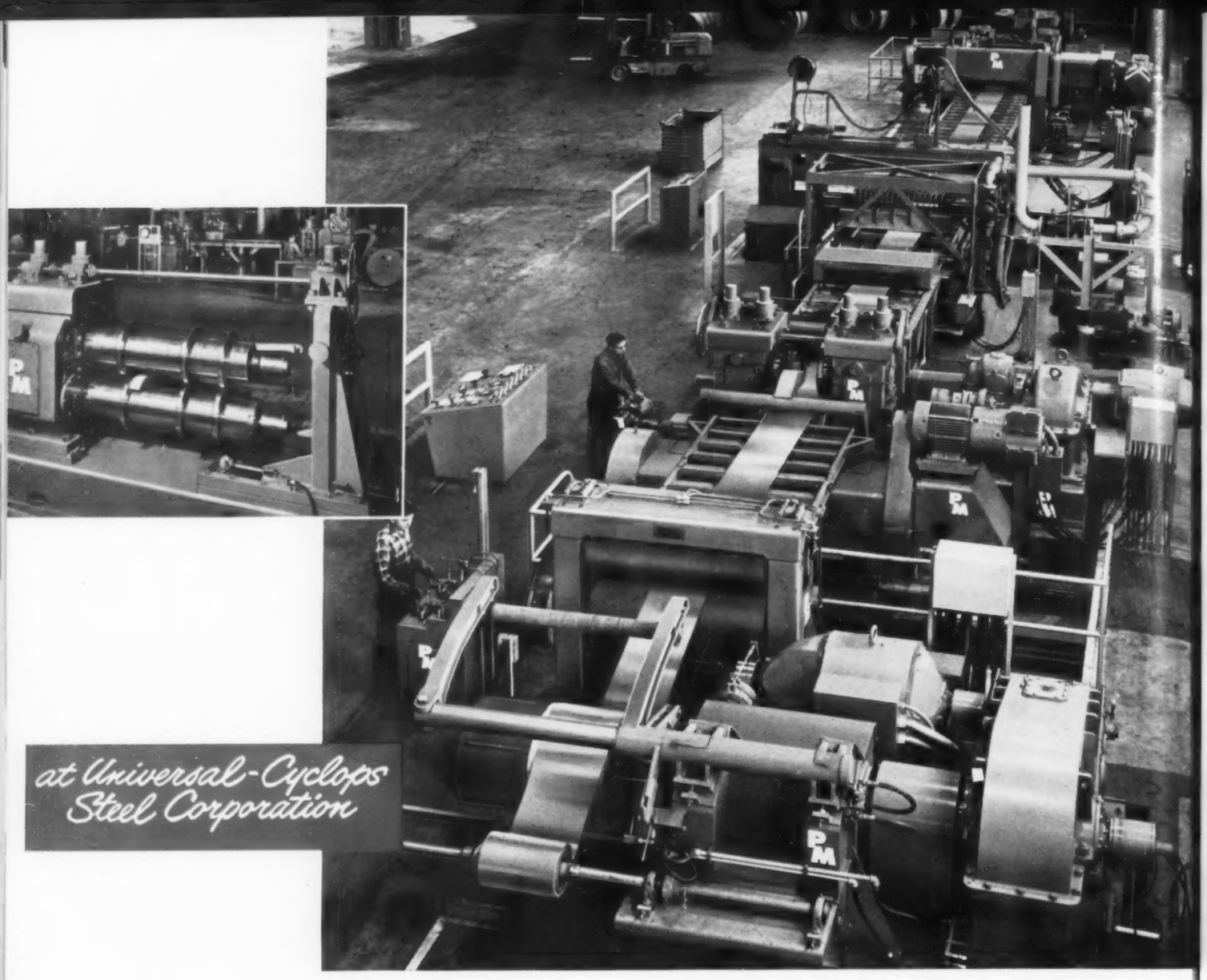

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P/M convertible, multi-purpose coil build-up line welds, trims and slits wide heavy gage stainless coils

By utilizing P/M's "Productioneering" in the design of their new Coil Build-Up Line, Universal-Cyclops was able to combine welding, edge trimming and slitting operations into a single high-speed installation at their new Coshocton, Ohio plant.

This heavy-duty, versatile, multi-purpose line handles hot-rolled unannealed stainless coils up to 0.250-inch in thickness and 50 inches in width. It welds smaller coils end-to-end to produce larger coils — which help cut processing time — for subsequent annealing, cleaning and pickling operations.

Normally the line is set up to side trim the moving stainless bands — but by moving the trimmer unit to one side and placing an interchangeable arbor assembly (shown in small photo) in the line, the facility doubles as a slitting line.

Here's another cost-cutting result of P/M's "Productioneering" — the exacting design of production-boosting metal processing equipment designed to fit users' specific needs. Next time you are planning installation of any of the type equipment listed below, call in a P/M engineer. He'll give you the complete story of what "Productioneered" equipment can do to improve your operations — build increased profits.

Production Machinery Corporation, Mentor, Ohio

P M ®

Designers and Builders of Metal Processing Lines and Equipment including: lines for pickling, annealing, slitting, shearing and cutting-to-length, grinding, scouring, coil build-up, inspection, and other sheet and strip processing lines and machinery.

J. W. SCHUETZ

F. A. ALEXANDER, JR.

R. W. KENYON

C. F. SIMMERS

held engineering positions with Westinghouse Air Brake and the Cooper Bessemer Corp.

T. J. Peters, as director of plant engineering and construction of Acme Steel Co., has been named to assume the responsibilities of **Walter F. Hinkle,** vice president—engineering, who retired November 1. Mr. Peters started his career in the steel business at United States Steel Corp.'s South works, as an electrical engineer in 1930. He held various engineering and operating positions at the South works leaving as division superintendent in charge of plant maintenance, construction and salvage to join Acme in 1954 as director of maintenance and construction. He was placed in charge of plant engineering and construction in 1959. Mr. Hinkle, who had just recently completed 35 years with Acme Steel Co., joined the organization as an engineer. He was named director of engineering in 1951, and was elected vice president—engineering in 1954.

James W. Schuetz was named chief engineer of the tube mill and cold draw equipment, Aetna-Standard Division, Blaw-Knox Co. He succeeds the late **Gus Mandry.** Mr. Schuetz joined Aetna-Standard in 1956 as a design engineer. Until his appointment, he had been project engineer. His former associations include Continental Foundry & Machine Co., 1953 to 1956; and Mesta Machine Co., 1948 to 1953. **Robert J. Rau** was named assistant chief engineer design—tube mill equipment. He joined Aetna-Standard in 1956 and was formerly with Continental Foundry & Machine Co. and Mesta Machine Co. At the same time, **Paul L. Beacom** was named assistant chief engineer design—cold draw equipment. He joined Aetna-Standard in 1929. He became chief draftsman in 1943 and project engineer in 1956.

Frank A. Alexander, Jr., was named to the newly-created position of assistant general manager, Rust Furnace Co. He has been with Rust since 1951 when he joined the company as a project engineer.

Glenn V. Prible, former assistant chief engineer, succeeds **H. Hayward Dinneen,** now vice president and general manager, as chief engineer. Mr. Prible was made assistant chief engineer in 1960. He joined Rust Furnace in 1953 as a design draftsman. **Francis H. Bricmont** becomes assistant chief engineer.

Russell W. Kenyon has been appointed vice president of sales, Kerns United Corp. The appointment fills the post left vacant by **Bruce W. Glenn** who was recently named president of Kerns Lubricants Limited, Toronto, a newly formed Canadian company. Mr. Kenyon has been in the Kerns organization for seventeen years. Prior to his appointment he was general sales manager of Kerns United and served as Eastern regional sales manager for the firm from 1954 to early 1960.

Charles F. Simmers has rejoined The Morgan Engineering Co. as vice president of engineering, the position he left in 1959 after 11 years of service to become a steel mill consultant. He later became associated with Koppers Co., Inc., as chief engineer of the Engineering and Construction Division.

W. W. Dyrkacz was appointed manager of quality control of Allegheny Ludlum Steel Corp.'s newly organized Bar Products Division. He will be responsible for directing the plant quality control departments at the Dunkirk and Watervliet plants. **R. J. Pfisterer** was appointed plant manager, Dunkirk, N. Y., and **T. C. Sells** was appointed plant manager, Watervliet, N. Y. **W. H. Tuck, Jr.,** was named division manager of purchasing and will be responsible for directing the plant purchasing activities at Dunkirk and Watervliet.

Edward H. Richard has been named sales manager—magnetics for The Ohio Electric Mfg. Co., subsidiary of Howell Electric Motors Co. Before joining the company's magnet sales organization in 1959, Mr. Richard performed a survey on mechanization in the scrap industry, in conjunction with the Institute of Scrap Iron and Steel.

John H. Covode, formerly manager of special product sales for the Controls Division, Hagan Chemicals & Controls, Inc., has been assigned to the Company's new Cleveland district office. He joined Hagan in 1939 as an engineer in its Hall Laboratories Division. He served in district and sales engineering posts in Cincinnati, returning to Pittsburgh in 1958.

J. R. Kirwin has been named assistant manager of gas sales for Air Reduction Sales Co.'s Philadelphia district. Mr. Kirwin has been associated with Airco since 1951 when he began as a sales trainee. After serving as an engineer in the Equipment Sales Department,

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Q. M. BLOOM (left)
G. D. DILL (center)
A. L. THURMAN (right)

he was appointed a salesman in the Boston district, in 1954. Last year Mr. Kirwin was named assistant sales manager for the Buffalo district, a post he held until his recent appointment.

Quentin M. Bloom has been appointed manager of the new Steel Mill Furnace Division of Selas Corp. of America. Named to executive sales positions are **Robert E. Buckholdt, Harry E. Morton** and **John L. Wilson.** Mr. Bloom rejoins Selas after a period of years at Weirton Steel Co. where he was assistant combustion engineer.

Gilbert D. Dill has rejoined Wheelabrator Corp. as staff assistant to the president. He directs the firm's program of development and research on new applications of blast cleaning equipment for the steel mill field. For two years previous to this appointment, Mr. Dill had been a private consulting engineer to steel and wire manufacturers in the field of blast cleaning and materials handling methods. Formerly, he served 14 years with Wheelabrator. Prior to joining the firm in 1944, he had been connected with the steel industry for 20 years.

Astor L. Thurman has recently been appointed general manager of McNally-Bird Engineering Co., Ltd., Calcutta, India, a new company recently formed by The McNally Pittsburg Mfg. Corp. and Bird & Co. Ltd. Most recently he was vice president of Lombard Corp. Prior to that he was manager of the West Virginia works of Connors Steel Div., H. K. Porter Co., Inc., in Huntington, West Va., and executive vice president of Mannesmann-Meer Engineering & Construction Co.

M. M. York has been named to the newly-created position of general manager of Allis-Chalmers Manufacturing Co.'s cement, mining and process departments. Since January of this year, he has been director of industry co-ordination for the Industries Group of Allis-Chalmers. Mr. York joined the company in 1939, and following completion of the company's training course for graduate engineers, was assigned to the Charlotte, N. C., district as a sales representative. He was appointed manager of the Boston district in 1950 and manager of the New England region a year later. In 1954 he was named manager of the Industries Group's north central region, with headquarters in Chicago. He remained in that capacity until 1960 when he was appointed manager of marketing for the Industrial Equipment division in Milwaukee.

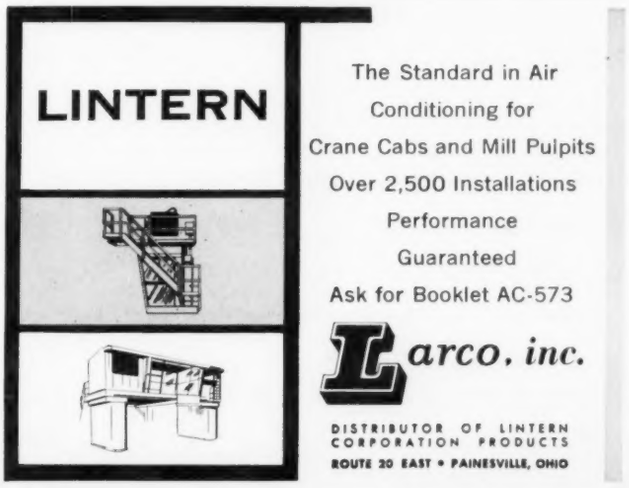
John W. Hutchinson Jr., has been appointed motive power market manager of The Electric Storage Battery Co.'s Exide Industrial Marketing Division, succeeding **O. L. Robertson** who will handle special assignments on national sales accounts in the telephone field. For the past two years Mr. Hutchinson, as national motive power market supervisor, has worked with Mr. Robertson in the motive power field. From 1955 to 1959, Mr. Hutchinson was a resident sales engineer in Springfield, Mass. He joined Exide at Boston in 1955. Previously, he was an electronics technician with the General Communications Co. Mr. Robertson, who was manager of the Service Engineering Division from 1957 until his appointment as motive power market manager in 1959, has been with Exide for 33 years. From 1945 to 1957, he was branch sales manager in the Dallas area.

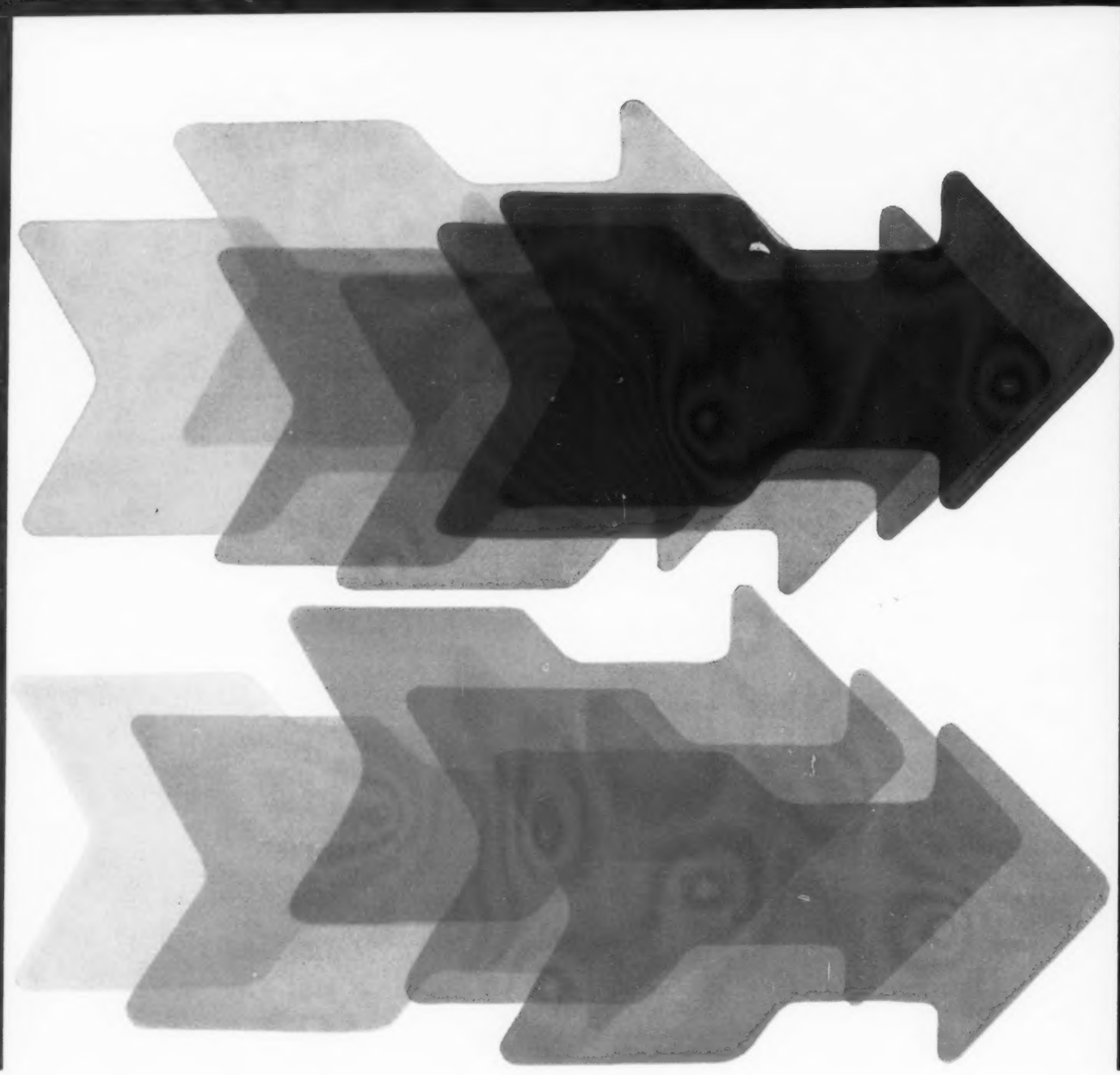
Harry F. Kurz has been appointed to Link-Belt Co.'s newly-created position of manager, distributor and warehouse sales, and **Edward C. Burg** has replaced Mr. Kurz as a distributor representative.

Obituaries

George T. Gilliard, 55, works engineer at the Butler, Pa., works of Armco Steel Corp., died November 9. He joined Armco in 1936 as a draftsman and was appointed a mechanical engineer in 1942. He also served as chief draftsman for a brief time in 1944 before becoming works engineer.

Peter Payson, 63, assistant director of research for Crucible Steel Co. of America, died November 26.





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Vital to your new plant's early profitability—and KE is a master at it!

Performance for others is frequently an excellent indication of the way a given organization will serve your needs. During almost a half-century, Kaiser Engineers has established its reputation for completing engineering and construction assignments on time, on budget. If you are contemplating new facilities or expansion in steel making, in minerals recovery and processing, in power generation or in the nuclear field, contact your nearest KE office. The head of a specialist group in your industry will call and describe how KE has served others, can serve you.

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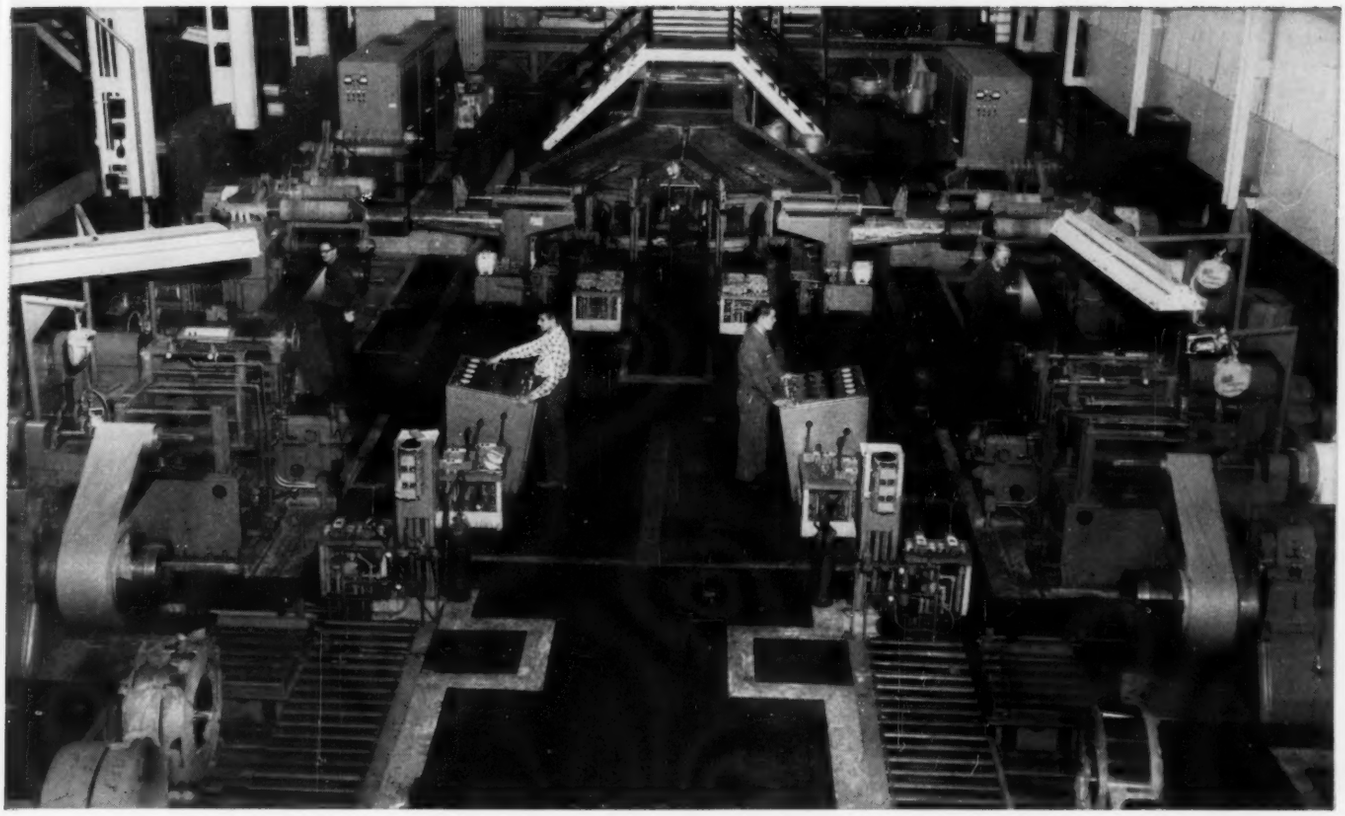
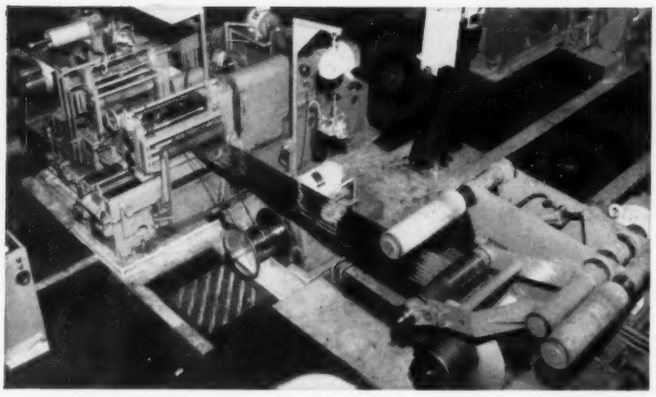
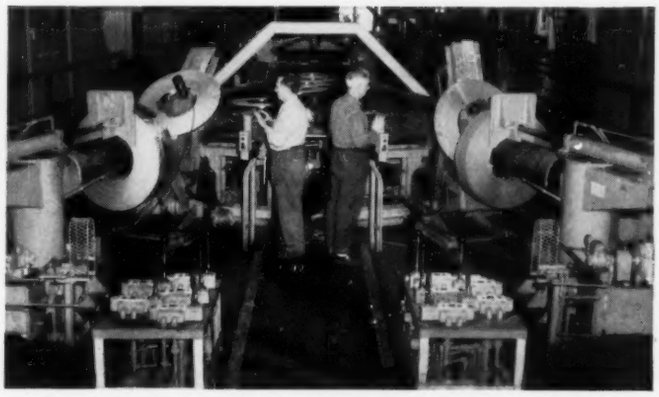


Predictable Performance...





SECO Slitting Installation, Superior Steel Division, Copperweld Steel Company, Carnegie, Pa.

is automatic—start to finish—with a SECO *Slitting Line*

SECO STEEL MILL EQUIPMENT

- Leveling and Shearing Lines
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- Tension Reels for Strip Polishers
- Narrow Strip Grinding Machines
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- Strip Coilers (Up and Down Type)
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- Steel Coil Up-enders
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Affiliated with Lee Wilson Engineering Co., Inc.

SECO

Every operation in this *complete* slitting line by SECO—from entry to exit of coils—is fully automated. It was specifically designed and built by SECO to meet the maximum performance requirements of the Superior Steel Division, Copperweld Steel Company, Carnegie, Pennsylvania.

SECO's staff of experienced sales engineers, specialists in production problem solving, are prepared to show you how you can get "predictable performance" in *your* operation—whatever your requirements. Call or write today. West Coast representative: United Machine Tool Company, Los Angeles, California.

STEEL EQUIPMENT COMPANY

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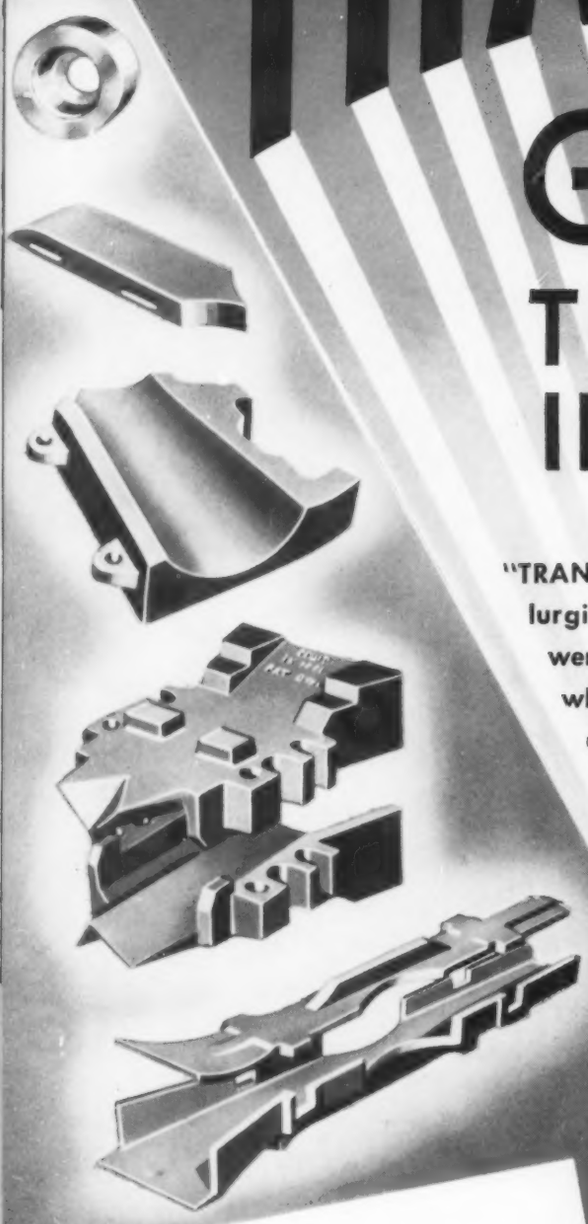
TRANTINYL GUIDES THE STEEL INDUSTRY



"TRANTINYL" offers a quarter-century of metallurgical experience. "TRANTINYL" patented alloys were developed to function in specific operations where guides are required to resist wear and abrasion. Users of "TRANTINYL" alloys are astounded at the tonnage rolled over one set of guides.

Join the many satisfied users of "TRANTINYL."

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bar, hoop, strip, shape mill guides; and rollers.

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guide shoes, rolling mill plugs and rolls, piercer points, etc.

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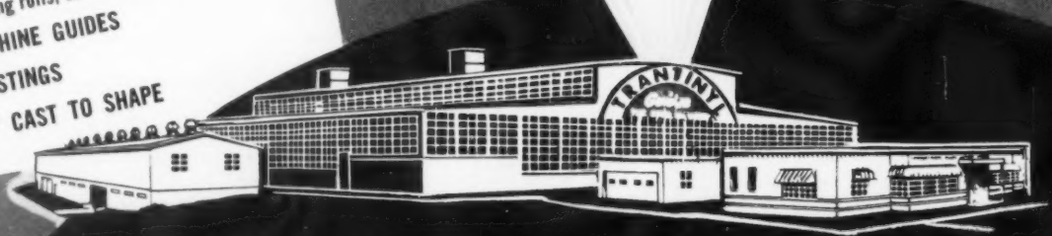
STRAIGHTENING MACHINE GUIDES

HEAT RESISTING CASTINGS

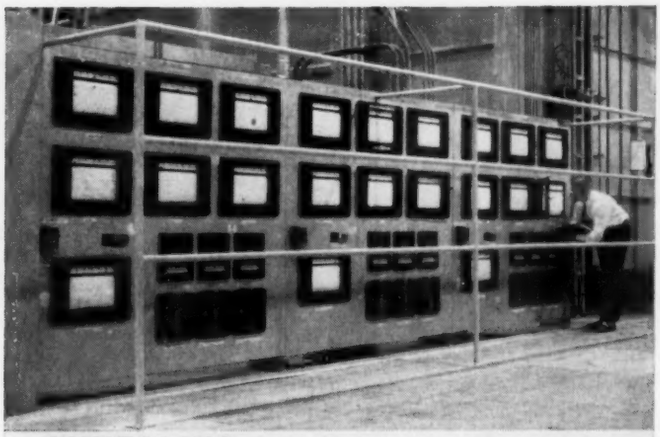
"TRANTINYL No. 1" CAST TO SHAPE



Youngstown Alloy Casting Corporation

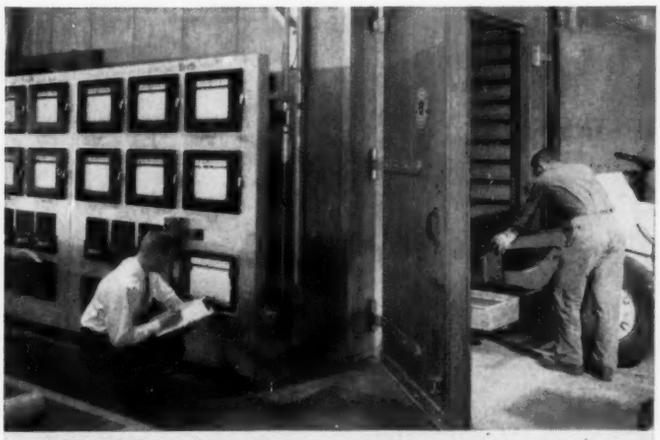
Youngstown, Ohio

SOAKING. These Bristol Dynamaster* instruments monitor soaking pit operation in new, multi-million-dollar aluminum fabricating plant of Anaconda Aluminum Company at Terre Haute, Indiana. Staff engineer analyzes record.



ANNEALING. Dynamaster* instruments here control and record annealing furnace temperatures in new Anaconda Aluminum plant. Over 11½ acres under one roof, the new plant produces aluminum sheets, extrusions, tubes and ingots.

HEAT TREATING. Anaconda staff engineer checks temperature records, produced by Bristol Dynamaster instruments, for vertical extrusion heat-treating tower, part of which is shown at left.



AGING. Dynamaster instrument panel at left controls and records temperatures in aging furnaces in new Anaconda Aluminum Company plant. Furnace operator at right is moving rack car into furnace.

BRISTOL INSTRUMENTS FOR THE METAL INDUSTRY

The key to higher quality, more uniform production, greater efficiency

Bristol offers pyrometers for every requirement: Electronic potentiometers (including miniature models), millivoltmeter and radiation types... for furnaces, ovens...every type of heating equipment, every kind of fuel.

Bristol Dynamaster* electronic potentiometer pyrometers, service-tested and proved in thousands of industrial plant installations, fully measure up to the requirements of today's most advanced steel and metal-working plants. Check these modern features:

1. Continuous standardization—eliminates usual standardizing mechanism and dry cell... no interruption to control.

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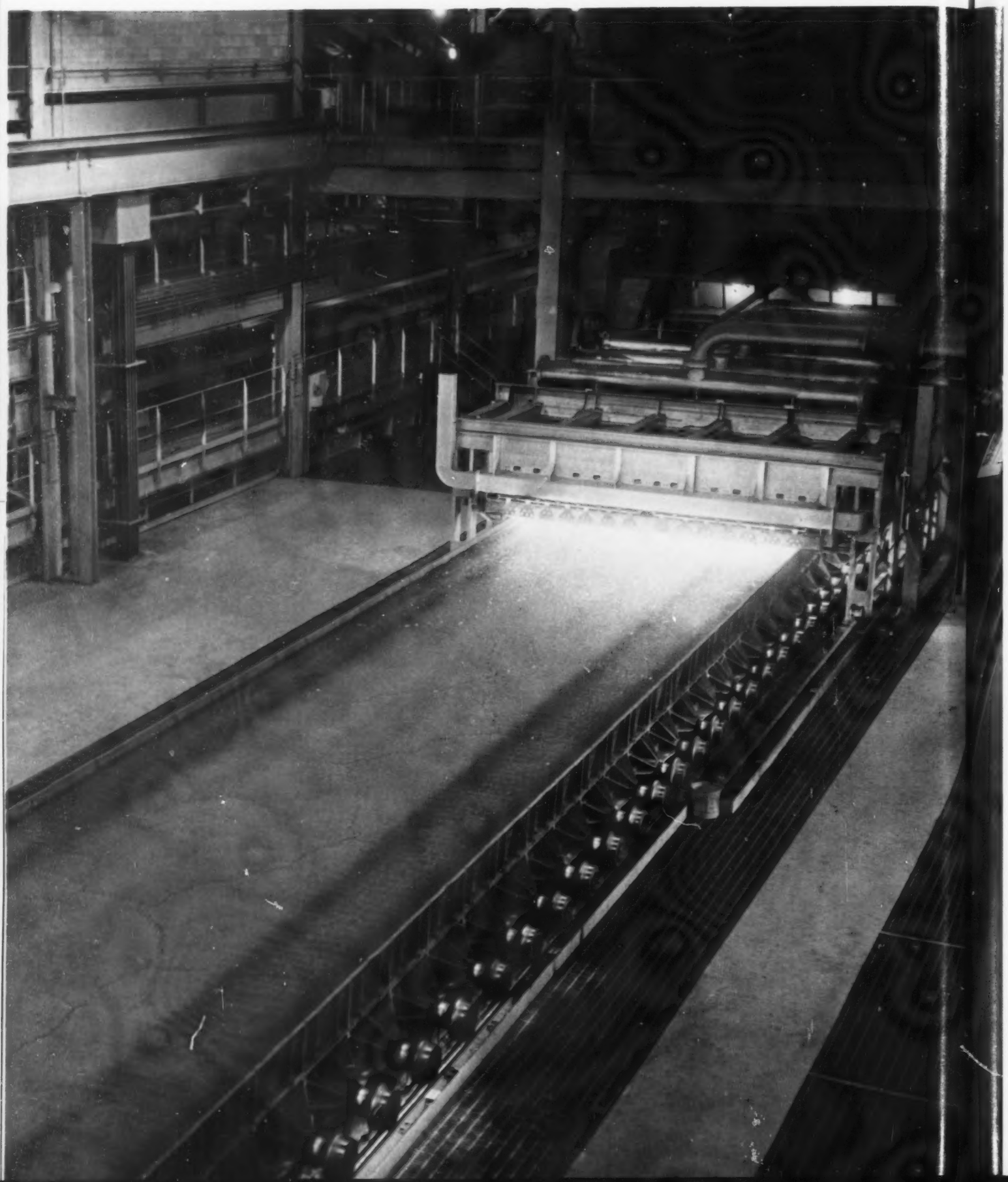
Write for complete data—and remember, Bristol markets a complete line of pyrometer accessories available for fast delivery to keep your plant in operation. The Bristol Company, 123 Bristol Road, Waterbury 20, Conn. *T. M. Reg. U. S. Pat. Off. O.8

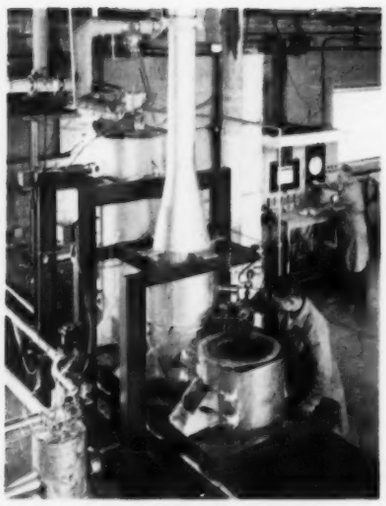
BRISTOL ...for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

Agglomerates, Researches, Docks, Co



ks, Concentrates, Handles, Builds

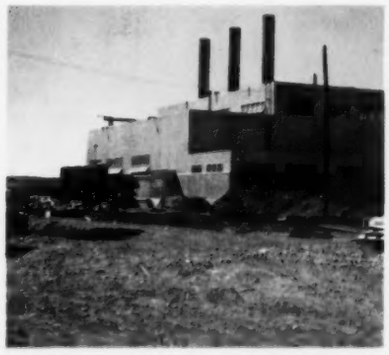


DOCKS: Large barge fleets dock at this steel company riverside facility to deliver raw materials or pick up outgoing shipments. Dravo pioneered cellular, sheet pile dock construction and has built them of all sizes for all types of industry. Dravo's 60 years' experience in heavy and marine construction can help you on projects such as docks, harbors, shafts, tunnels, foundations, water intakes. Check coupon below for information.

RESEARCHES: Dravo research explores agglomeration processes and establishes bases for plant design of complete pelletizing, sintering and briquetting facilities. Second Dravo-Lurgi ore pelletizing plant for a major metal producer is underway. Dravo-Lurgi iron ore sinter plants account for 45% of new U.S. capacity added in last 5 years. Mail coupon for facts.

CONCENTRATES: Interior of a Dravo-Lurgi magnetizing-roasting kiln, where low grade, non-magnetic ore is reduced to synthetic magnetite for separation by conventional equipment. Two pilot plants, one 10-ton per hour and one 2-ton per hour, are now in service in U.S. Use coupon for data on ore beneficiation processes.

HANDLES: 15-ton capacity ore bridge handles stocking and reclaiming needs of large steel producer's expanded yard. Dravo ore and coal unloaders and container cranes speed handling at mills, industrial plants, power stations, terminals and ports. For information on this equipment, check and mail the coupon.



BUILDS: One of five turn-key steam plants built for major auto maker. Other construction services include Dravo-Linde AG air and gas separation and Stora-Kaldo oxygen steelmaking plants; power and compressor stations; piping, machinery, pumping and water or waste treatment installations. Check coupon.

AGGLOMERATES: Total hearth area of 2,419 sq. ft. (13.17′ x 183.75′) makes this Dravo-Lurgi facility the world's largest single-strand sinter plant. Use coupon.

DRAVO

Dravo Corporation, 4780 Grand Avenue, Pittsburgh 25, Pa.

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☐ Sinter Plants & Coolers	☐ Turbo Blowers	☐ Steam Plants
☐ Pelletizing & Briquetting	☐ Space Heaters	☐ Fabricated Piping
☐ Oxygen Steelmaking	☐ Ore Bridges	☐ Grating

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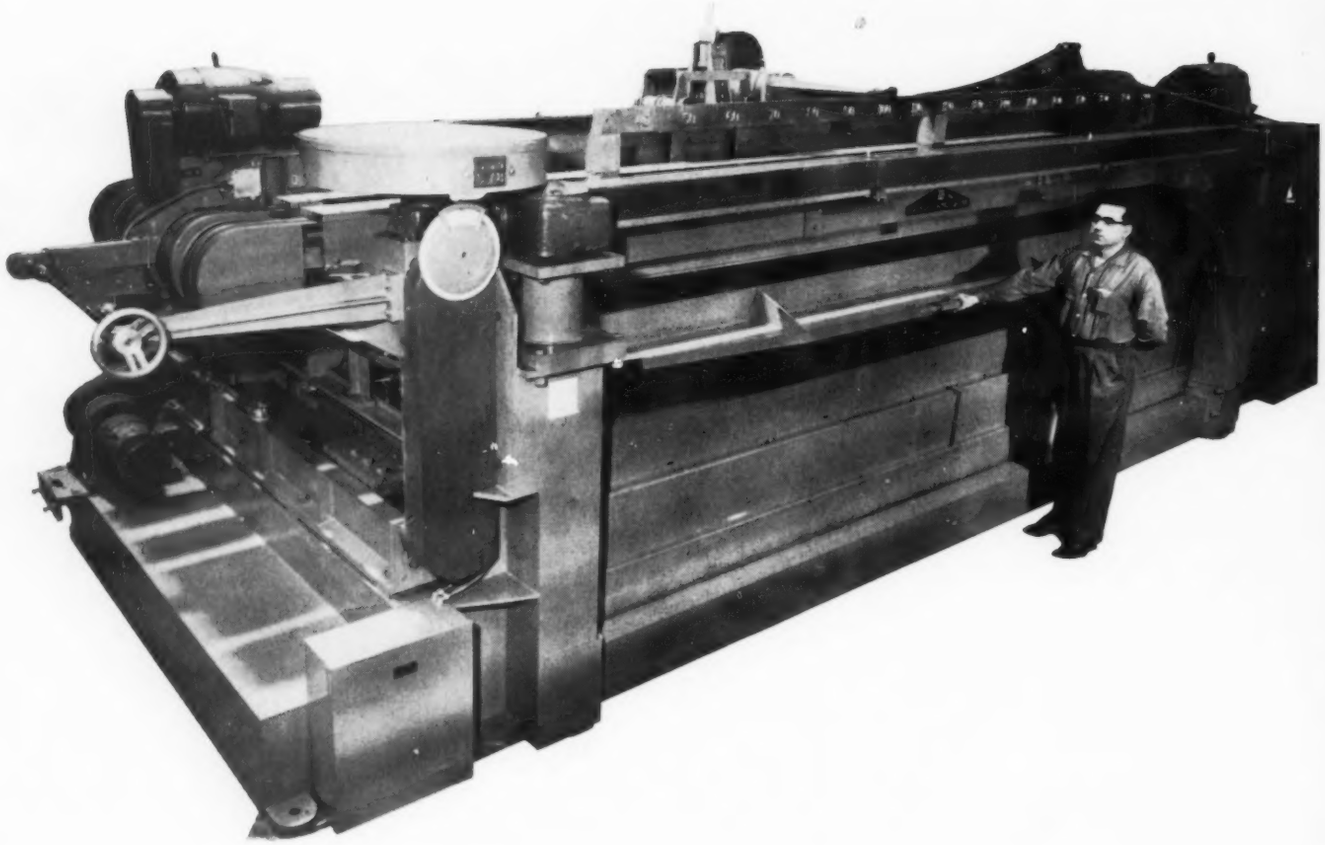
NO EXCAVATIONS REQUIRED FOR BUCCICONI PILER AND LIFT



New, 75″ wide x 200″ long x ¼″ thick sheet handling capacity, Bucciconi magnetic sheet piler features a lift unit with ball bearing screws incorporated in its design. No excavations are required and the machine mounts directly on floor level. A driven roller conveyor is also incorporated for end discharge of the finished pack.

When fully accounting the deduction in quality that takes place as each sheet slides and scratches, the sliding rig installations are very expensive to operate. The Bucciconi piling system is based on sound principle that the sheet is conveyed by magnetic or vacuum power from its top surface and then gently released on the pile. The use of this principle saves money for the producer and the ultimate user of the material processed.

Act now by sending your specifications—we will reply promptly with literature or quotation.

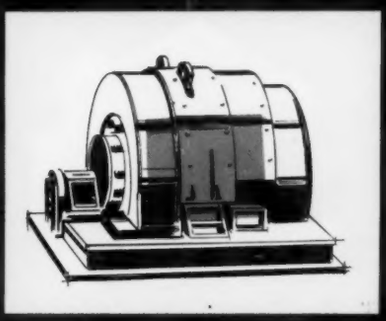
BUCCICONI ENGINEERING COMPANY INC.

PIONEERS AND MANUFACTURERS OF MAGNETIC AUTOMATION MACHINERY FOR HANDLING STEEL SHEET AND STRIP
MANUFACTURERS OF MAGNETIC CONVEYORS, MAGNETIC SHEET PILERS AND DE-PILERS, MAGNETIC ROLLS, MAGNETIC PROXIMITY INDUCTO-SWITCH, THE D. B. MICROGAGE, AND TIN PLATE ASSORTING EQUIPMENT.

899 GRANT STREET GARY, INDIANA U. S. A.

STEEL IS ROLLED AT THE HOMESTEAD WORKS WITH AN ASSIST FROM NATIONAL BRUSHES

TRADE MARK



Rolling mills at the Homestead Works of United States Steel Corporation exert tremendous pressures to squeeze steel into desired thicknesses. The mills are designed to handle terrific mechanical strains ...the motor-generator sets to take the swinging peak loads imposed.

"National" Brushes—wherever they are used on the m. g. sets that power the mammoth mills—provide good commutation and life despite the difficult loading conditions. They contribute to dependable service with minimum commutator maintenance.

To help improve electrical operations, we offer a positive carbon brush service program. Just call your "National" Brush Man or write National Carbon Company, Division of Union Carbide Corporation, 270 Park Avenue, New York 17, N.Y. In Canada: Union Carbide Canada Limited, Toronto.

Contact your "National" Brush Man

UNION CARBIDE

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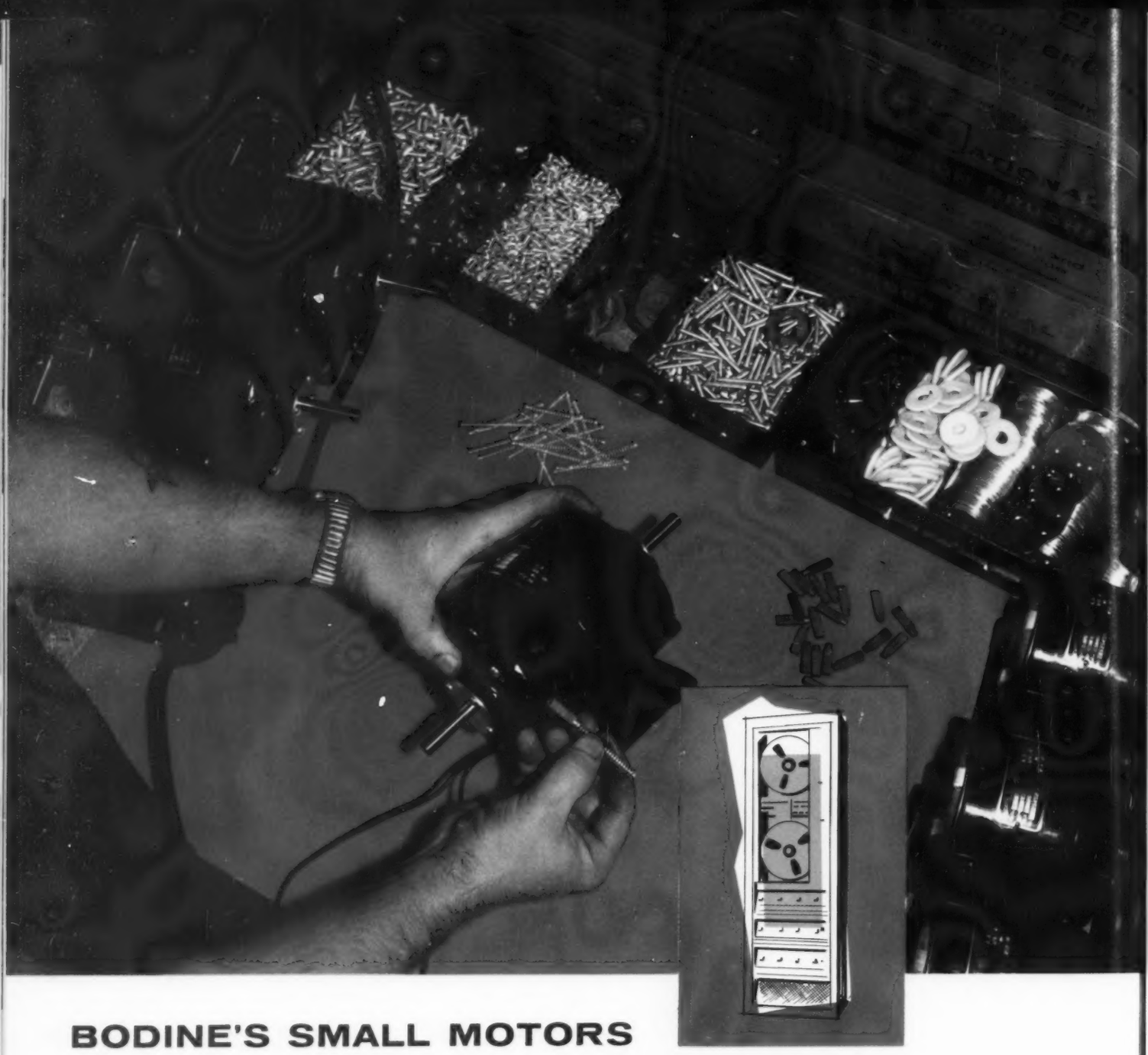

BODINE'S SMALL MOTORS OFFER DEPENDABLE SERVICE WITH AN ASSIST FROM NATIONAL BRUSHES

TRADE-MARK

Here, at the Bodine Electric Company Plant, fractional horsepower motors are manufactured for a wide variety of products. Considering the small sizes of the motors used, these products do a tremendous job in making many everyday tasks easier and more enjoyable for the user.

"National" Fractional Horsepower Brushes—tiny but vital components in these motors—offer proved dependability so necessary in this small equipment.

National Carbon Company maintains a complete testing laboratory specifically designed for the investigation of fractional horsepower brush problems. For information, contact your "National" Brush Man or write National Carbon Company, Division of Union Carbide Corporation, 270 Park Ave., N. Y. 17, N. Y. In Canada: Union Carbide Canada Limited, Toronto.

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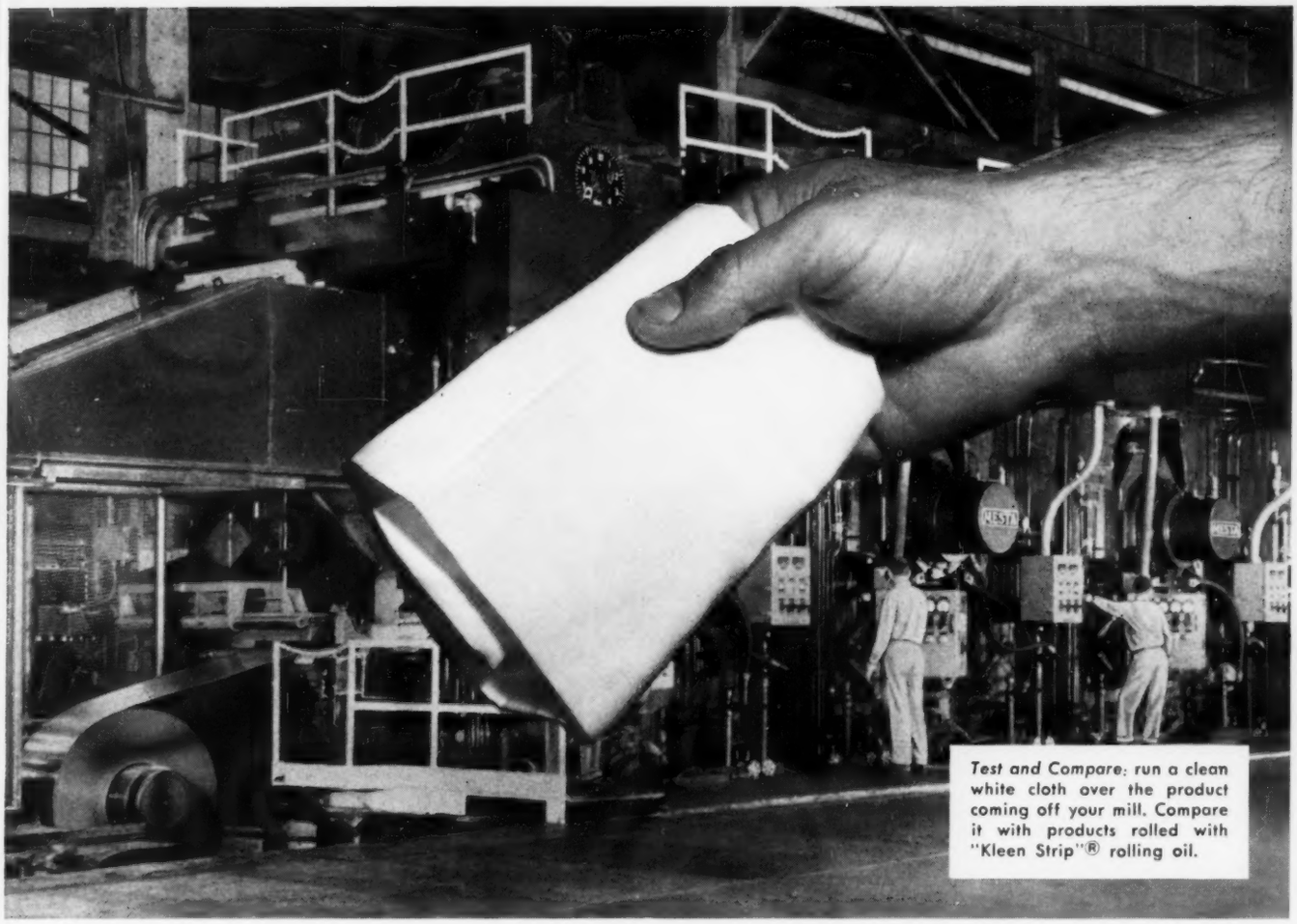

Test and Compare: run a clean white cloth over the product coming off your mill. Compare it with products rolled with "Kleen Strip"® rolling oil.

Does your sheet come off the mill this clean?

Rolling oil is a critical component in cold reduction mill operation. The *right one* can improve your yield and increase profit. Kerns United has proved it. Mills now rolling with "Kleen Strip" repeatedly report results of cleaner, more profitable sheet and strip.

The reason: "Kleen Strip" rolling oils are personalized to meet specific mill requirements. Mill performance, and product being produced are considered and a compatable compound formulated. You obtain a rolling oil that delivers the cleanest possible strip, one that delivers the reductions and tonnages you are looking for at optimum efficiency.

Let us prove what this personalized approach in formulating rolling oils can mean to your cold reduction mill operations. Mill test a recommended "Kleen Strip"* Rolling Oil at no risk to you using the Kerns United Memo Billing basis. No formal invoice entered unless completely satisfied. Call, wire, or write today for full information.

Here's what you can expect of *personalized* "Kleen Strip" rolling oils . . .

Cleaner product — "Kleen Strip" gives you cleaner strip off the mill and through the anneal. Burns clean, doesn't stain.

Greater yield — "Kleen Strip" helps you make easier and greater reductions. Helps you get down to gauge fast for greater prime yield, increased tonnage.

Consistent performance — You obtain consistent performance year in and year out from "Kleen Strip" . . . an oil with uniform quality from shipment to shipment. And "Kleen Strip" rolling oils are stable in storage . . . stable in use.

Faster mill start-ups — From Kerns United you get a complete, chemically compounded product. No additives are required. This simplifies control, gives you faster mill start-ups with less problems.

PERSONALIZED LUBRICANTS FOR INDUSTRY

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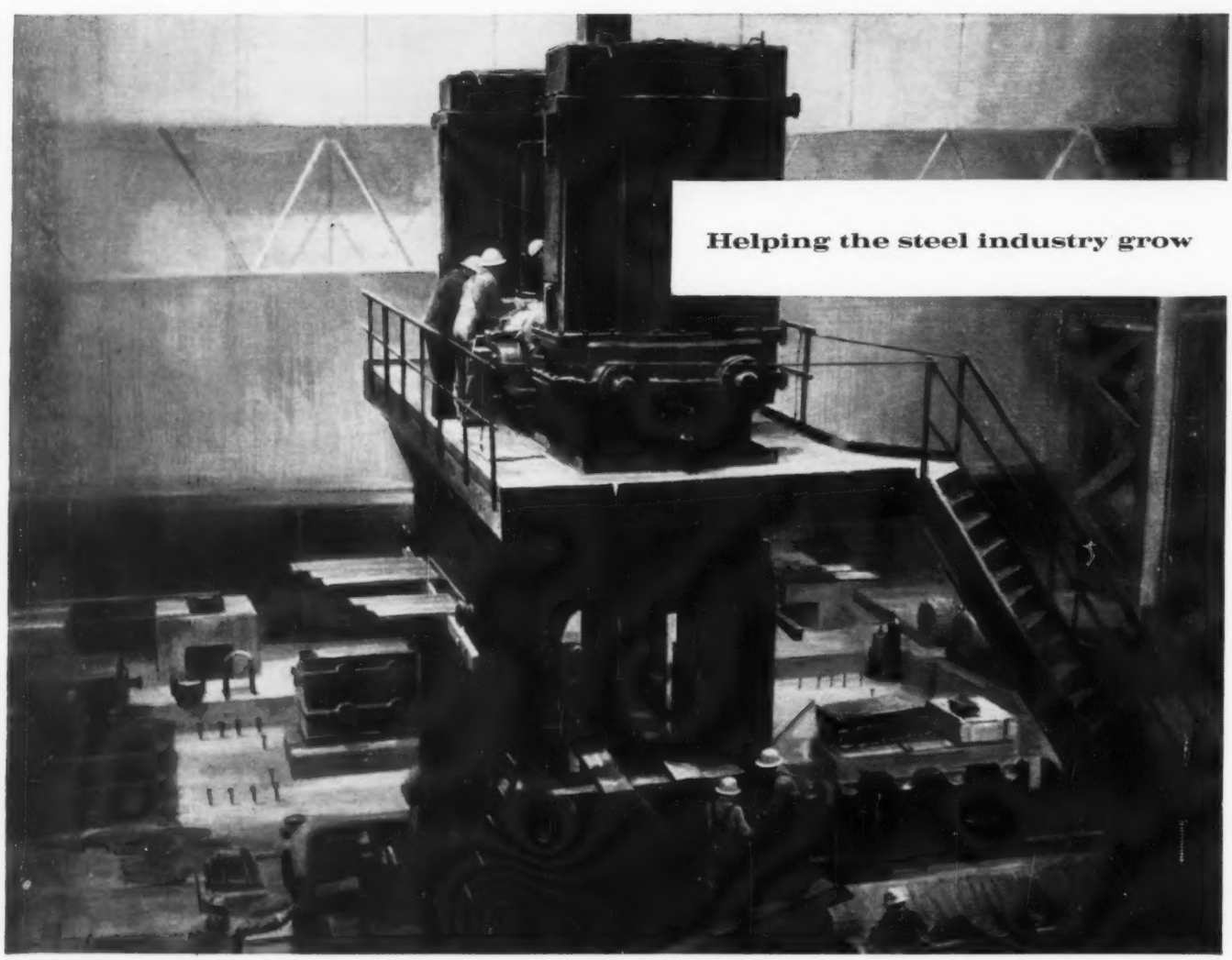
On schedule with a new mill

Majestic in its massiveness, a giant rolling mill dominates the scene in a new steel plant rising to completion. With knowledge strengthened by practice, skilled workmen delicately assemble and adjust a machine that will squeeze and flatten red hot ingots to usable dimensions. To keep work on schedule and within your budget, United Engineers coordinates design, purchasing and construction all under one authority. And our constantly accumulating experience benefits every client. For over 75 years, the variety of steel mills, power stations, industrial installations and process plants that we have completed has progressively broadened. Proof that we serve our clients well is reflected in the fact that most of them consult us again. On your next project, why not discover how well we can serve you.

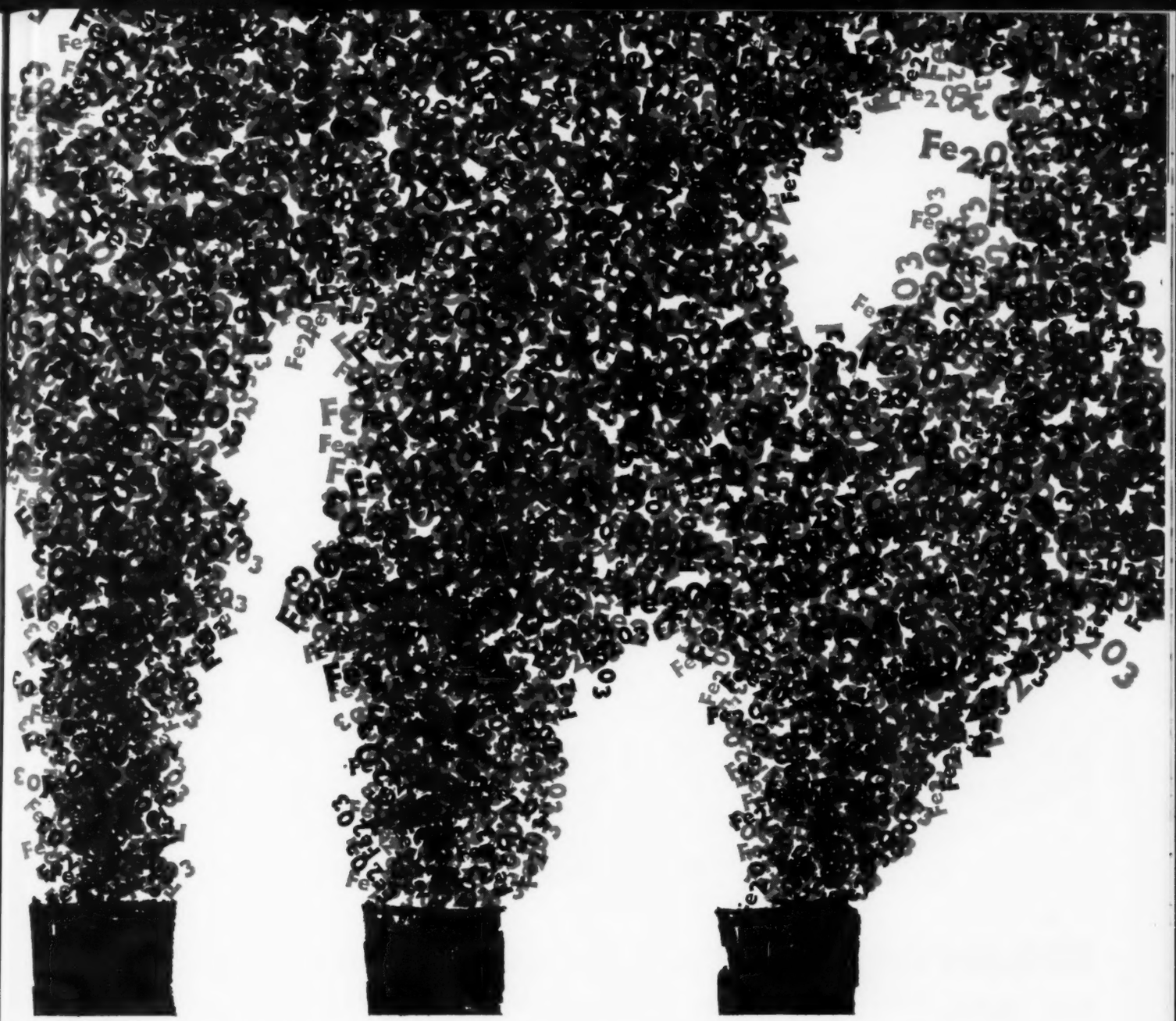
Painting by Robert Lavin



Helping the steel industry grow

UNITED ENGINEERS

& Constructors Inc. • U.E.&C. (Canada) Ltd. • New York • PHILADELPHIA • Chicago



USING O_2 IN YOUR OPEN HEARTH? Chemico Venturi Scrubbers do more than simply solve the air polution problems brought on by the use of oxygen in steel making. Operating and performance figures indicate that for oxygen steel converters, oxygen lanced open hearth furnaces, electric furnaces and flame scarfing, the Chemico Venturi Scrubber solves those problems with higher efficiency and at lower cost than any other method now in operation. Specifically, these are the advantages of a Chemico Venturi Scrubbing System:

CAPITAL INVESTMENT—Chemico Venturi Scrubbers can be installed for approximately 30-50% less capital cost than required for electrostatic precipitators.

OPERATING AND MAINTENANCE COSTS—Chemico Venturi Scrubbers require so little maintenance and manpower, that over-all operating costs are dramatically lower than for other methods, even though power requirements may sometimes be slightly higher.

CONSISTENT PERFORMANCE—The Chemico Venturi Scrubber attains maximum cleaning efficiency at start-up. This peak efficiency is not decreased by subsequent changes in the gas flow or other variations in process conditions.

COLLECTION AND DISPOSAL—The Chemico Venturi Scrubber collects iron oxide dust wet and recovers it dry—free of contaminants and ready for re-use. It eliminates the common and very serious problem of how to handle and dispose of dry dust collected in an electrostatic precipitator.

WATER REQUIREMENTS—The Chemico closed cycle scrubbing process eliminates water disposal problems and cuts make-up water requirements to a minimum. Normally, no more than 50-100 GPM is needed.

PROCESS FLEXIBILITY—Adjustable Venturi throat permits automatic control of furnace draft while maintaining full cleaning efficiency.

If you are considering the installation of gas cleaning equipment, a Chemico representative would be pleased to discuss performance and cost figures with you. Chemico handles the complete job:

PLANNING—DESIGN—ENGINEERING—CONSTRUCTION and START-UP.

CHEMICO

Chemical Construction Corporation, Gas Scrubber Division, 320 Park Ave., New York 22, New York

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Ask a BEARINGS, INC. engineer to survey your production machinery. He may be able to suggest and recommend bearings that will increase production at lower cost. Change-overs from plain bearings to anti-friction bearings are a specialty with us.

Call the BEARINGS, INC. branch nearest you NOW!

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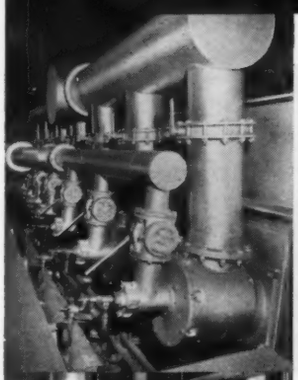

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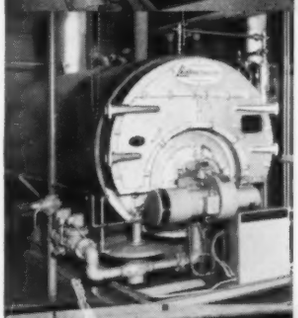
Gas, Oil, Dual-Fuel. Long, short, flat, luminous, or clear flames.

General purpose burners and burners designed for radiant tubes, immersion tubes, railroad car thawing, air heaters, kilns, forge furnaces, steel mill furnaces, incinerators.

For cold or preheated air, excess air, excess fuel.



PACKAGED AUTOMATIC BURNERS — for boilers, dryers, ovens, air or oil heaters.

Gas, Oil, Dual-Fuel. 20 to 600 boiler hp; .8 to 25 million Btu/hr.

UL, FM, and FIA approved. 100% of combustion air supplied by fan.

Packaged units with fan, valves, control cabinet, pilot, transformer, pump, and compressor.

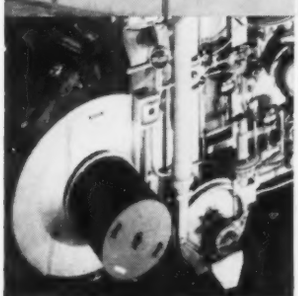
COMBUSTION CONTROLS —

Hydraulically operated pressure, flow, and fuel/air ratio controls.

Pneumatic pressure and ratio regulators. Gas-Air Mixers.

Control valves with electric, pneumatic, or hydraulic operators.

Limiting orifice valves, safety shutoff valves.



TURBO BLOWERS — 4 to 44 ounces per square inch.

60 to 14,300 cfm. ½ to 125 hp. 1800 and 3600 rpm.

Direct, V-belt, or coupled drives. 1, 2, 3, or 4 stages.

With electric motors; steam turbines; gas or diesel engines.

Variety of inlet and discharge fittings, accessories, positions.

EDGE CONTROLS — for pay-off, wind-up, intermediate process steering, belt tension, speed control.

Electric eye and air jet edge detectors.

Hydraulic edge guide regulators, power units, cylinders.

Compact and light weight. Fast, accurate, and powerful.

NORTH AMERICAN for COMBUSTION and Hydraulic Controls

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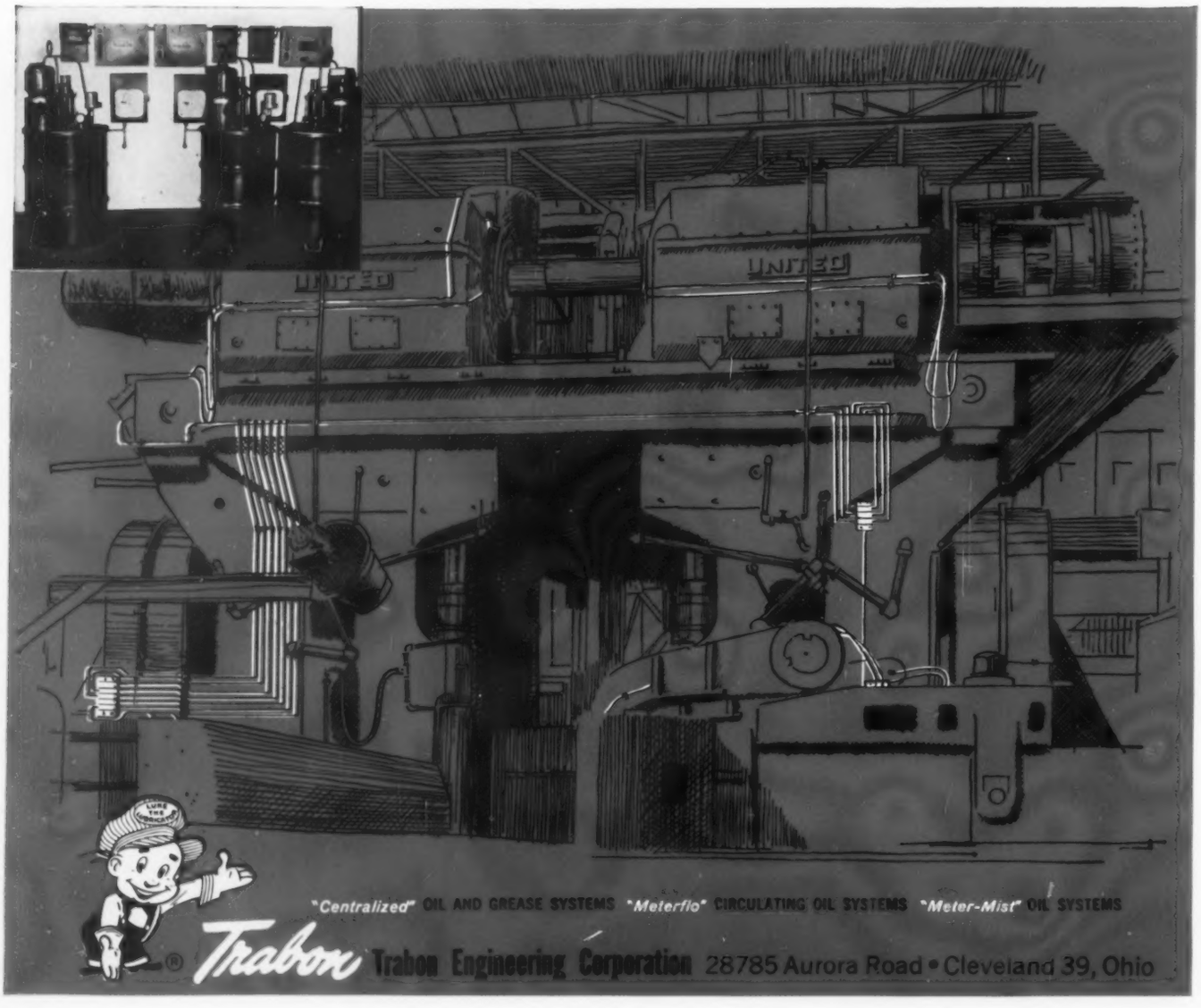
CENTRALIZED LUBRICATING SYSTEMS

When tonnage has to be made, Republic Steel's modern 45″ slabbing mill can really make it. But tonnage depends on the mill operating efficiently day after day and that's where Trabon Centralized Lubricating Systems help. Trabon automatically delivers exact amounts of grease to all bearings on the mill, runout table and manipulator. Some bearings demand grease on a 5 minute "on" — 10 minute "off" schedule. Other bearings need grease less frequently. Trabon does all these critical greasing jobs positively. The small inset photograph shows the Trabon control panels and hydraulic barrel reservoirs which "time" the delivery of the lubricant throughout the mill area. In addition, each bearing has built-in Central Warning to alert the work crew in case a line is smashed or blocked in some way. This explains why steelmen rely on Trabon for **production** and profit **protection.** Why don't you call a Trabon representative for full details today.

Republic Steel's 45″ slabbing mill lubricated by Trabon

Nothing left to chance — Central Warning protects profits


"Centralized" OIL AND GREASE SYSTEMS "Meterflo" CIRCULATING OIL SYSTEMS "Meter-Mist" OIL SYSTEMS
Trabon
Trabon Engineering Corporation 28785 Aurora Road • Cleveland 39, Ohio

Equipment News...

NICKEL-IRON BATTERIES

△ New Type E Exide Nickel-iron alkaline batteries, marketed and serviced by Exide Industrial Marketing Division, The Electric Storage Battery Co. can match the capacity of some of the most powerful batteries designed to power electric industrial trucks in heaviest-duty, longest-shift material handling operations.

Like their predecessors they produce electric current by the transfer of oxygen from the nickel oxide of the positive plate to the sponge iron of the negative plate, in an alkaline electrolyte.

But, they have been completely redesigned to make much more efficient use of available space. They are now capable of producing 100 amp-hr per positive plate. They now produce 1.202 watt-hours per cu in., up from 0.68 watt-hours in the former design.

The new nickel-iron alkaline batteries require no alterations in standard compartments of most trucks, including the critical height dimension. They still are 22⅝ in. high and fit standard compartments.

Exide believes the capacity increase will greatly broaden the utility of nickel-iron alkaline batteries, enabling many types of trucks to work harder, longer shifts with less frequent battery charging.

With increased battery capacity small trucks that can work in narrow aisle spaces will be able to handle heavier workloads; trucks will have greater ability to use power attachments that increase their versatility, lifting speeds and usefulness; fewer spare batteries will be needed on charge while others are at work, because the nickel-iron alkaline batteries can work longer on one charge; fewer sizes of batteries will be needed, because the more powerful units can be used interchangeably in more types of equipment.

The new "E" line is designed for use in many types of counterbalanced sit-down and stand-up, center-control and end-control fork-lift rider-type trucks; pallet-type and fork-lift hand trucks and tractors.

Initially, the E line is available in five standard electrical sizes—400-, 500-, 600-, 700- and 800-AH capacities—adequate for trucks rated up to 8000-lb lifting capacities.

Later, Exide plans to bring out larger models of the new battery for heavier trucks and to convert other nickel-iron lines (used in other applications) to the new design, all with comparable capacity increases.

The capacity boost has been accomplished by design innovations that increase the percentage of power-producing materials per cube of battery.

The perforated nickel-steel tubes that contain the positive active material now run from the top to the bottom of the plate. They are reinforced by seamless steel rings around them. Previously, rows of parallel tubes, fastened end to end on a grid, were used to span the length of the plate.

Similarly, perforated steel strips that contain the negative active material now run the entire length of the negative plate. Previously, the negative active material was contained in rows of short rectangular pockets pressed onto a grid framework.

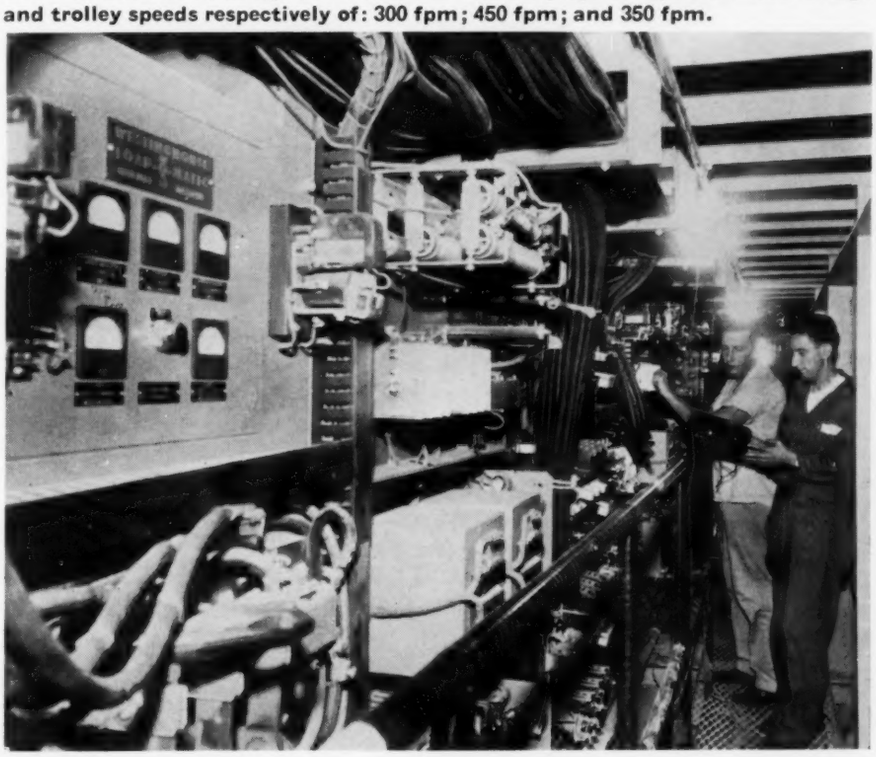
Thus, the plates are almost solid masses of active materials.

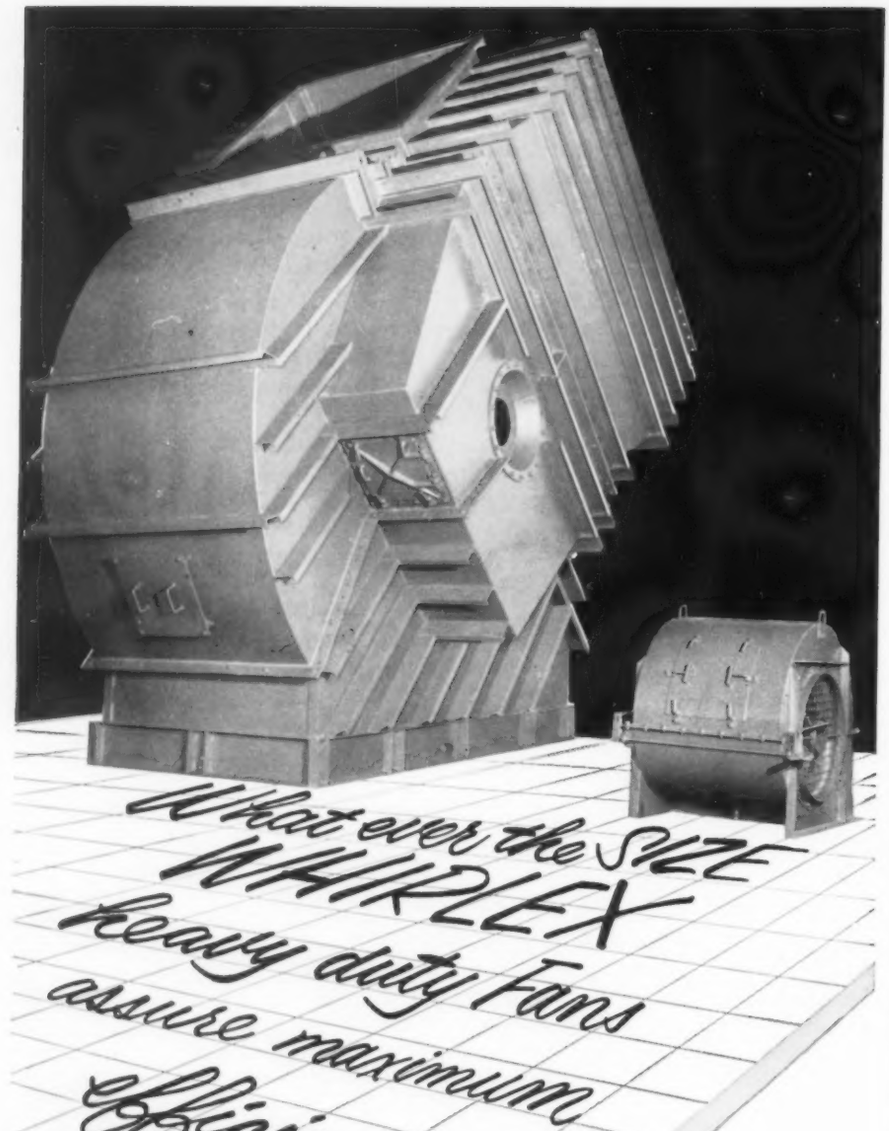
The positive tubes are held in place by all-welded construction to bars at top and bottom. The nega-

▲

LARGE BOX GIRDER CRANE IN SERVICE

Milwaukee Crane Div. of Novo Industrial Corp. has delivered a 150-ft span box girder crane to the Dundee Cement Co., Dundee, Mich., for use in a clinker storage hall. The very long span crane has a number of novel features. The crane's trolley rails are mounted toward the inboard edges of the girders both to reduce the trolley span and to counter balance the weight of the electrical control equipment which is installed within a walk-in pressurized girder. A-c reactor control is used throughout and is especially suitable in co-ordinating the four individual bridge drive motors. The duty cycle required hoist, bridge and trolley speeds respectively of: 300 fpm; 450 fpm; and 350 fpm.





WHIRLEX fans and dust collection equipment offer the maximum in efficiency regardless of the size or operating conditions. A wide variety of designs, metals and linings are available to you from WHIRLEX!

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Bag Collectors ■ Mechanical Collectors ■ Wet Collectors
Induced Draft Fans ■ Forced Draft Fans ■ Exhaust Fans
Self Supporting Stacks ■ Duct Work

tive strips are crimped together, fastened at both top and bottom, and corrugated laterally across the face for extra structural rigidity.

Support of the plates is provided by a rack at the bottom of the cell. Round plastic pins between the plates and steel connecting rods with steel spacing washers between the tops of the plates provide proper insulation and separation.

Wooden trays in which the interconnected cells of nickel-iron batteries were assembled have been eliminated. Instead, the cells now are assembled in space-saving steel cradles in sizes to fit standard truck compartments.

These changes have made it possible to increase the capacity of cells within each standard cradle. They also have made it possible to increase the number of positive tubes by 25 per cent per plate, the length of the plates by one third.

The cell terminals now are straight instead of tapered. These not only provide better electrical conductivity, they also make it easier to remove connectors, a simple Allen wrench sufficing instead of a special jack and wrench.

All the important parts—containers, pole pieces, connecting rods, tubes, strips—are made of steel. The electrolyte, a solution of potassium hydroxide in water, is a steel preservative. A small quantity of lithium hydroxide added to the electrolyte increases the electrical capacity of the battery and the life of the battery itself.

The active material, freely accessible to the electrolyte through the tube and strip pocket perforations, cannot be dislodged. Thus, there is a minimum loss of electrical capacity during the life of the cell, and sediment does not accumulate at the bottom of the cell.

The positive active material is alternated with layers of nickel flake within the tubes to give better electrical conductivity. The new improved negative active material is now in continuous strips to give maximum plate capacity.

The cell containers are of nickeled steel, with all seams welded. Cell covers, also of nickeled steel, are welded to the container.

The new batteries, like their predecessors, are guaranteed for the entire lifetime of low-lift electric

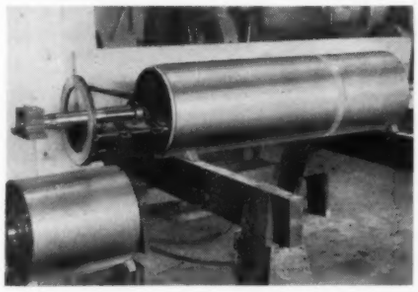
hand trucks, no matter how long they last in any type of one-cycle-per-day material handling operation.

Only proviso—even if the multi-purpose hand trucks last 20 years or more, as many of them do—is that users charge and maintain the batteries properly with approved equipment.

MAGNETIC HEAD PULLEY

△ The 82 in. wide by 18-in. diam Type IV Lorig-aliner roll pictured (with one end pulley removed to show a portion of the permanent magnet) is said to be the first time that a Type IV Lorig-aliner roll and permanent magnet have been combined into a single head pulley.

The roll assures accurate, continuous alinement and tracking of



the 80-in. wide rubber belt in spite of frequent off-center positioning of heavy surge loadings.

The permanent magnet is mounted on a frame inside the roll, and does not rotate with the roll. It has a 150-deg arc. The position of the magnet inside the roll can be changed, to any desired position, to vary the amount of "pull" imparted to the material for removing tramp iron and other foreign materials, also to alter the trajectory and location of the storage pile when the belt is handling pelletized ores and other magnetic materials.

The company reports that this first combination roll and magnetic pulley has proved very satisfactory in service, and that the company is prepared to furnish similar positive belt alining magnetic head pulleys in a wide range of widths and diameters to meet any requirement.

SILICON RECTIFIER

△ A newly-compact, general-purpose industrial silicon rectifier, which provides dependable, efficient operation, lower first cost, installation and maintenance savings over other

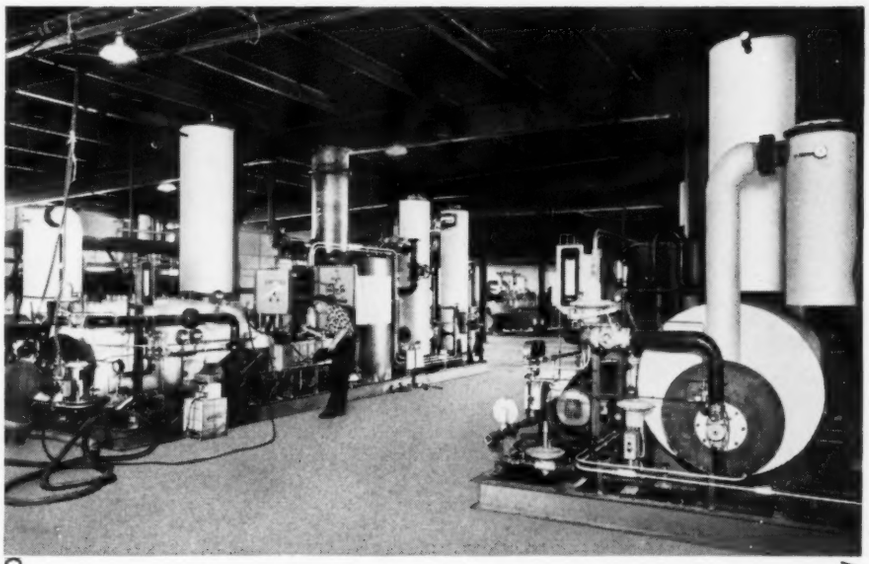
PACKAGED GAS GENERATORS PACKAGED GAS GENERATORS PACKAGED GAS GENERATORS PACKAGED GAS GENERATORS PACKAGED GAS GENERATORS

EVEN THE BIG ONES ARE FACTORY ASSEMBLED AND THOROUGHLY TESTED AT GAS ATMOSPHERES

The pair of 10,000 cfh high-purity nitrogen generators pictured below is undergoing complete factory testing prior to shipment to the customer. This is standard practice at Gas Atmospheres.

GENERATORS MUST EXCEED SPECIFICATIONS in production, gas purity, and dryness. This rigorous testing assures buyers of quick and easy start-up without job-site disorder, and it cuts servicing and maintenance to the bone.

GAS ATMOSPHERES ORIGINATED PACKAGED GAS GENERATION SYSTEMS by increasing the productivity of various components, consolidating operations, and designing the unit into as compact an area as possible. This means smaller generators today produce greater volume, and the entire unit can be factory assembled on a common base and shipped and installed as a complete unit.



Two compact 10,000 cfh high-purity packaged nitrogen generators on test floor at Gas Atmospheres Assembly Plant.

IF YOU USE GAS, EVEN IN SMALL AMOUNTS, it might pay you to produce your own with a modern gas generation system. It costs nothing to have your operation checked out by America's foremost designer and builder of packaged gas generation systems. Just call or write *Gas Atmospheres, Inc., 5353 West 161st Street, Cleveland 35, Ohio.*

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equipment for producing industrial gases

PACKAGED GAS GENERATORS PACKAGED GAS GENERATORS PACKAGED GAS GENERATORS PACKAGED GAS GENERATORS PACKAGED GAS GENERATORS

types of d-c conversion equipment, has been introduced by I-T-E Circuit Breaker Co.

The self-contained unit is for use in industrial and commercial applications where the d-c voltage is standard. For instance, the rectifier can provide d-c power for cranes, hoists, elevators, magnetic chucks, machine tools and any other general-purpose d-c applications.

The rectifier is available in one compact size for all ratings which range from 100 to 300 kw, 208 to 575 volts, 3-phase, 60-cycle a-c at 125 or 250 volts d-c. The unit has overload ratings of 125 per cent for two hours and 200 per cent for 10 seconds—following continuous loading at 100 per cent in either case.

It is said the rectifier can be purchased at 20 per cent less than other types of conversion equipment.

Factory-assembled, wired and tested, it incorporates all necessary equipment—from incoming a-c connections to outgoing d-c terminals—to form a single, compact, self-contained unit.

The silicon diode arrangement, in which the diodes are mounted on common buses, contributes to its compact construction by reducing the size of the rectifier assembly.

The complete rectifier measures only 58 in. high, 28 in. deep and 36 in. wide. It can be installed in less than eight sq ft, a saving of approximately 35 per cent in area required for other types of conversion equipment.

Compact construction of the new unit facilitates installation; affords on-the-spot conversion of a-c to d-c power.

The rectifier is ready for operation simply by moving it into place adjacent to the equipment it will power, then connecting the incoming a-c and outgoing d-c lines. Long runs of d-c cable, which can result in costly power losses, are not required.

Because the new rectifier requires no reinforced foundation, installation costs are also kept to a minimum.

The operating efficiency of the rectifier is substantially higher than other types of conversion equipment—from 25 per cent up to full load, efficiency is 96 per cent.

The use of new type high PRV silicon diodes and an improved cooling fin arrangement on the heat sink help provide for this increased efficiency.

Designed to be self-protective against overloads and short circuits, the self-contained unit assures reliable d-c service with minimum maintenance.

It features an a-c breaker and overcurrent relay, co-ordinated with nonaging, hermetically-sealed silicon diodes and indicating current-limiting fuses.

Diodes, each protected by a current-limiting fuse, are mounted on copper buses and connected to form a three-phase, full-wave bridge.

If the rectifier is subjected to a heavy overload or short circuit, the breaker opens before damage to silicon diodes and fuses can occur. This prevents costly plant shutdowns.

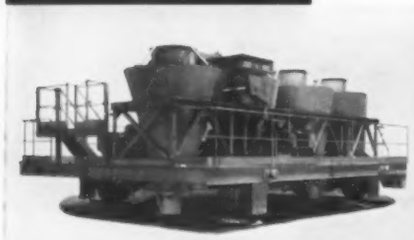
The rectifier will also continue to operate safely with one diode out of service on each half of the bridge. Should a diode failure occur, its companion current-limiting fuse iso-

QUENCHER LOCOMOTIVE

DOOR MACHINE

COKE
ON THE
MOVE

Operating economy and long life, again, are major advantages of Atlas equipment for highly specialized coke-producing service. Specially designed and ruggedly built to your exacting requirements.



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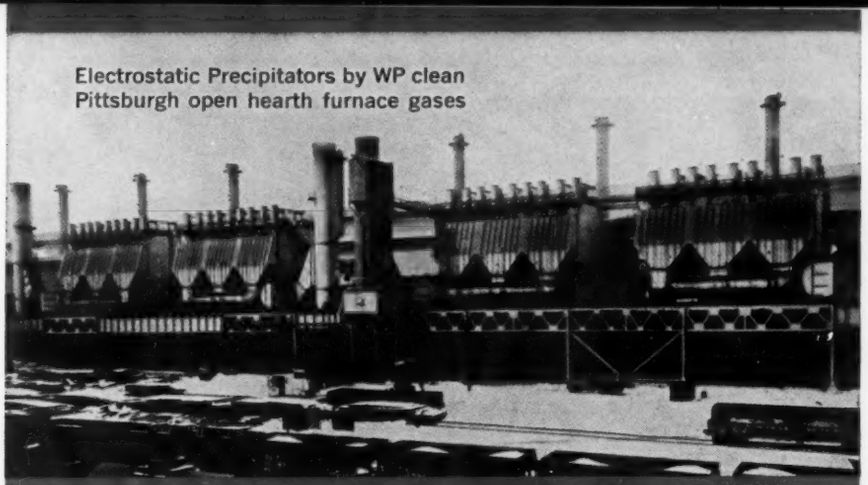
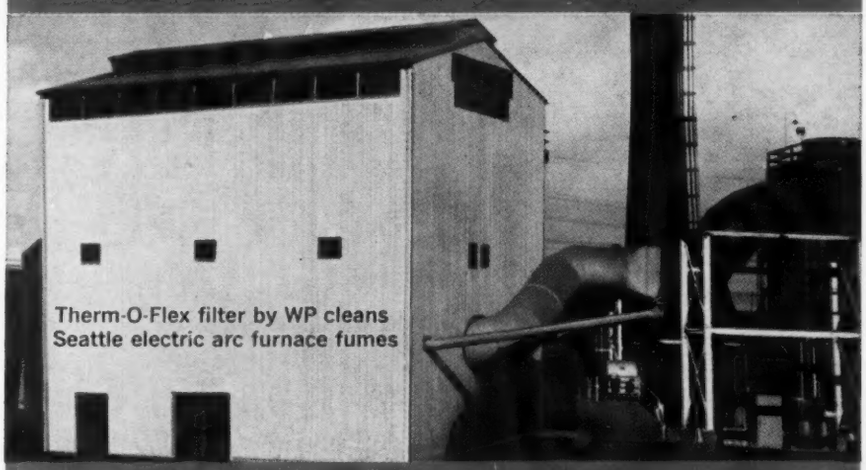


Electrostatic Precipitators by WP clean
Pittsburgh open hearth furnace gases

Open hearth steel in Pennsylvania... and electric arc in Washington... agree:



Therm-O-Flex filter by WP cleans
Seattle electric arc furnace fumes

When DUST is your problem— CLEAR IT WITH WP*

For an efficient, economical solution to any dust control problem—look to Western Precipitation. WP is uniquely fitted to handle your unique problem—being the one organization that custom designs, engineers and installs ALL types of dust and fume control equipment: Precipitator, Mechanical, Jet-Cleaned Filter, Hi-Temp Filter, scrubbers and engineered combinations.

With no axes to grind for any one system, WP engineers will give your job a completely unbiased recommendation—whether it's a quote on your specifications, a single component, or a completely engineered installation . . . small, major, simple, or complex.

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IDEAL FOR TAKING ROD SAMPLES AND OTHER CUTTING JOBS. Here is an exceptionally mobile and versatile hydraulic rod cutter. It has a capacity for ½" mild steel rod and will make the cut in a matter of seconds. The cutting head is light and easy to use . . . weighs only 6½ lbs. Unit is powered by 110 volt, ¾ horse power motor. Solenoid valve control operated by thumb button. Weight of entire unit only 100 lbs.

MANCO offers a complete line of hydraulic cutting tools, punches, rod straighteners. Write for Catalog.

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MANCO MFG. CO.

BRADLEY, ILLINOIS

lates the faulty diode, enabling the rectifier to remain in full-load operation until maintenance shutdown is convenient.

Location of the faulty diode is simple because of a built-in monitoring system.

Simultaneously with the operation of the current-limiting fuse, an alarm sounds; a signal light indicates that a diode failure has occurred; and a small, easily-seen plunger on the current-limiting fuse shows which diode is out of service.

Other protective features of the rectifier include protection against: a-c under-voltage; d-c overcurrent; insufficient air flow and transformer overtemperature. Capacitors are also supplied to protect the diodes against line switching surges.

Under such abnormal conditions, the rectifier shuts down or is prevented from starting until they are corrected.

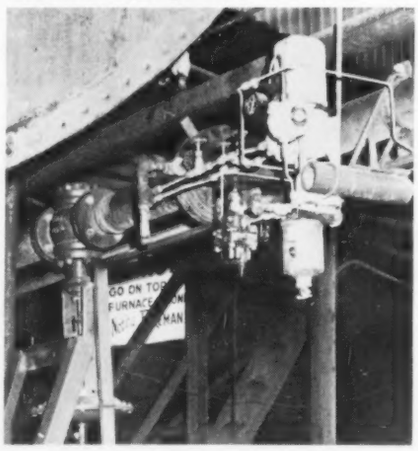
Shutdowns for routine maintenance are also minimized since the rectifier has no moving parts except fans.

FUEL INJECTION CONTROL

△ With the injection of gas, fuel oil and oxygen becoming widespread practice among blast furnace operators, the metering of these fluids into the blast stream in controlled quantities has become increasingly important.

Application engineering work carried on by The Foxboro Co., in conjunction with several leading mills, has proved the advantages of Type 13A d/p cell transmitters in the measurement of these flows.

Installation of a Type 13A d/p cell transmitter and control valve on natural gas injection to a blast furnace in a steel plant.



AMSCO reversing table gears give 6 to 7 times longer life

Problem: Carburized steel gears on the reversing table of a 44″ blooming mill *failed* every 2-4 months. Mill production *stopped* during replacement.

Solution: Amsco manganese steel mitre gears installed.

Result: Service life increased to over 18 months. Gear tooth spalling and breaking stopped.

Unusual? Not at all. We have records taken from the files of most major steel mills that show identical or better results under equally brutal conditions.

Amsco manganese steel gears make good sense. Their initial cost is usually less than carburized gears *plus* a service life up to 7 times greater.

If you are interested in stopping frequent mechanical shutdowns due to gear failure, check with your nearest AMSCO representative. He can recommend cost-cutting, production-boosting solutions to your problems.

1461

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AMERICAN MANGANESE STEEL DIVISION
CHICAGO HEIGHTS, ILLINOIS

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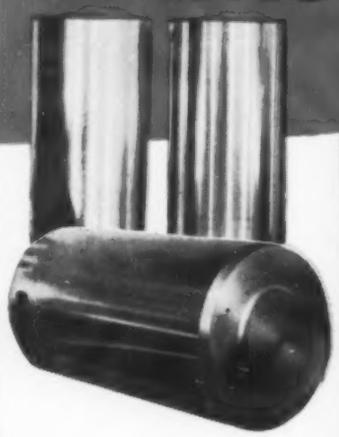
RED CIRCLE Rolls ALLOY-CHILLED

Hyde Park RAMS



for all types of HYDRAULIC EQUIPMENT

Hyde Park Rams are available in Chilled or Alloy Iron.

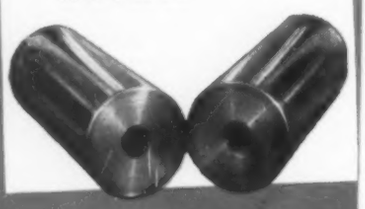
Furnished in hardness range to meet your specification . . . ground to your required size.

On your next replacement of Rams—or for new equipment—consult us. Our engineers will be glad to assist you.

Red Circle Rolls for every Purpose

Rolling Mill Equipment

Gray Iron Castings up to 80,000 lb.



Hyde Park FOUNDRY and MACHINE CO. HYDE PARK Westmoreland County, Pa.

Rolls
Rolling Mill Equipment
Gray Iron Castings

This instrument, with its twin-diaphragm capsule and force balance measuring system is highly accurate and responds to flow changes instantaneously. Connected across an orifice plate in the injection line, it senses differential pressure and transmits a pneumatic output to a flow controller which is preset to the rate of injection flow desired. The controller, in turn, throttles a control valve in the supply header.

Installations in blast furnace work to date cover the control of natural gas, fuel oil and oxygen injection flows. Steam injection has been measured in the same way, except that a measurement of blast moisture sensed by a Dewcel element is used to pneumatically set the control point of the flow controller.

To assure even distribution of the fuel around the furnace d/p cell transmitters are also installed on the individual downcomers from the injection line. These measurements are fed to indicators as a guide to manual adjustment of fuel flow or to controllers for automatic regulation of fuel distribution.

Results of accurately controlled injection include more efficient furnace operation, lower thermal requirements per ton and decreased coke requirements. In a typical installation, operating costs were reduced 15 per cent and fuel costs cut 17 per cent.

LIFTING MAGNET

△ Cooler operation, a ¾ time duty cycle and watertight construction are three benefits of Cutler-Hammer's new aluminum wound lifting magnets. The aluminum coil provides superior efficiency by affording cooler operation for higher lifting capacities, longer life, more dependable operation and lower maintenance costs.

The use of anodized aluminum ribbon for winding the coil eliminates the necessity of separate insulating ribbon between turns. New insulating techniques give these magnets higher thermal capacity and improved heat transfer capabilities which lengthen their life by reducing the possibility of damage from overheating.

The line includes welded magnets with diameters of 39 in., 45 in., 55

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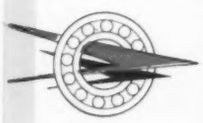

BERRY BEARING COMPANY

DAnube 6-6800

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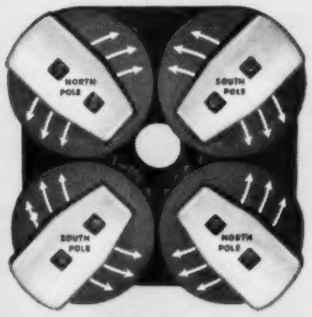
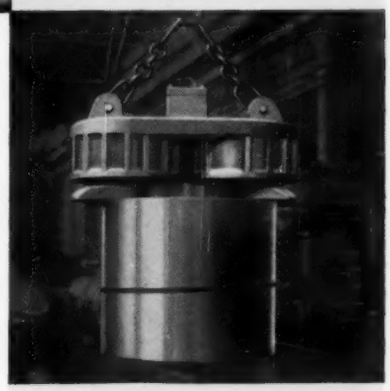
LIFTS THE COIL —NOT THE HOLE

Poles directly over coil wall give high flux density at each pole shoe contact.





Protect finished coil surfaces, Get better storage capacity *with*

EC&M type CSM Magnets

Exclusive Advantages of the CSM design:

1. Lifts coil without tilting — reduces chance of damage to bottom of coil when setting it down.
2. Nothing adheres magnetically to coil's bottom to damage it when it is again set down. Coil below is not disturbed when top coil is lifted from the pile.
3. Operator can center magnet on coil easily — magnet does not hide his view of the load.
4. Magnet can deposit coil in, or remove coil from, confined passages without disturbing surrounding piles or objects — minimum overhang allows compact storing.
5. Lifts coils weighing up to 80,000 pounds.

Type CSM Magnets are designed specifically to handle finished coils carefully and without delay. Coils are moved quickly and safely between roll stands and annealing furnaces, in and out of storage areas — and similar movements where protection of the finished product is paramount.

FOR A SPECIFIC PROBLEM, TELL US—

1. Inside and outside diameter of coil
2. Weight of coil
3. Gauge of strip
4. Type of coil (tightly or loosely wound)
5. How banded and how smooth on top (evenness of turns)

Ask for Bulletin 1312 which fully describes these magnets

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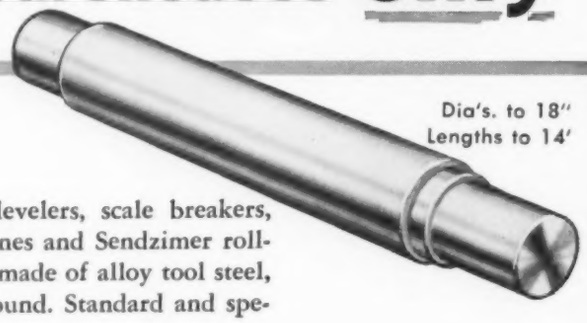
For STEEL MILLS

and warehouses *only*



Dia's. to 18"
Lengths to 14'

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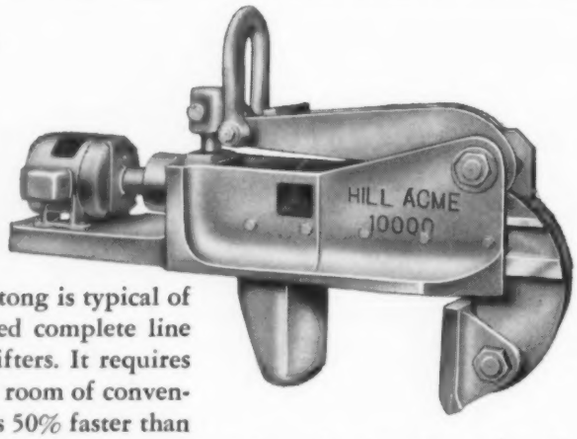
Custom made for levelers, scale breakers, straightening machines and Sendzimer rolling mills. Precision made of alloy tool steel, heat treated and ground. Standard and special types.

"CLEVELAND" METAL CUTTING KNIVES

The product of forty years of experience in manufacturing alloy grade, metal cutting knives of all types for shearing hot and cold metals.

"HILL ACME" MOTORIZED LIFTERS

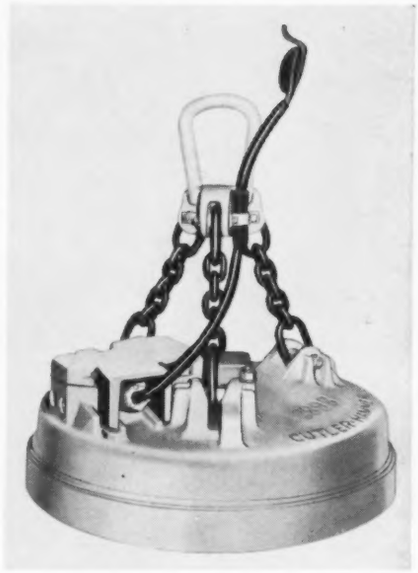


This vertical coil tong is typical of the newly designed complete line of HILL ACME lifters. It requires only 1/3 the head room of conventional tongs and is 50% faster than mechanical types. Gives a constant grip ratio regardless of wall thickness and can be prepositioned to eliminate damage to the coil. Available up to 80,000 lbs. capacity. Contact us for "C" hooks, Rack Lifters, Billet, Sheet, Plate, Bar, Ingot and Ingot Mould Lifters.

THE HILL ACME COMPANY

1201 West 65th Street • Cleveland 2, Ohio

MANUFACTURERS OF: "HILL" Grinding and Polishing Machines • "ACME" Forging Machines • "CANTON" Rotary and Alligator Shears • BAR-BILLET Shears MATERIAL HANDLING Equipment • "CLEVELAND" Knives and Shear Blades.



in. and 65 in. In addition, 59 in. and 69-in. magnets, as well as 59 in. and 69-in. deepfield magnets, are offered in the bolted pole shoe construction.

The watertight construction of this magnet provides added protection against the destructive effects of environmental moisture. It can also be used for underwater operations.

A new terminal box design incorporates a cover that will withstand blows from any direction without loosening or shearing cover bolts. The cover also provides protection for the cable at the point of entrance into the terminal box.

LEVELER

△ A new Vertoflex leveler has been developed by the Aetna-Standard Division of Blaw-Knox Co. for use in connection with the open coil annealing process.

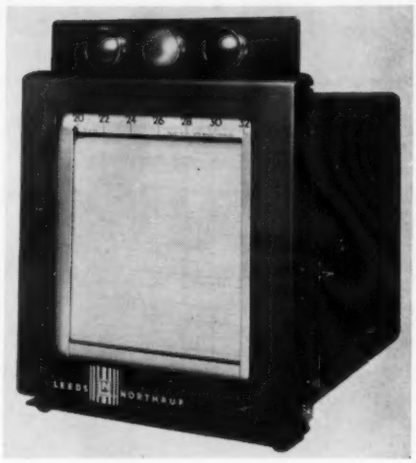
The installation of this leveler results in: prevention of coil breaks; elimination of edge defects caused by coils stacked on edge; better tracking; shape correction to the extent that temper rolling can be eliminated on certain products; tighter wrapped coils and production of 20-in. inside diameter coils of 16-gage material.

RECORDER

△ A portable Speedomax H signaling-recorder for use with "Temtip" expendable immersion thermocouples has been designed by Leeds & Northrup Co. to measure and record molten metal bath temperatures.

The recorder provides all the precision features normally included in Speedomax H instruments, plus portability. It can be used anywhere in the shop that a 120-volt, a-c supply is available. In addition, the instrument can initiate the familiar "green-amber-red" signal sequence using its integrally-mounted signal lights. These signals guide the operator through a satisfactory immersion cycle each time a temperature measurement is taken.

For steel-bath and similar temperature applications, the recorder's illuminated scale and chart are calibrated from 2000 to 3200 F for use with either platinum, platinum—10 per cent rhodium or platinum, platinum—13 per cent rhodium Temtip cartridges. For nonferrous baths, the range is from 1000 to 2500 F. Other ranges can also be supplied. Full-scale balancing time (span-step-response time) is two seconds; chart speed, four inches per minute. The recorder is supplied with a carrying handle, rubber bumper "feet," line cord with plug



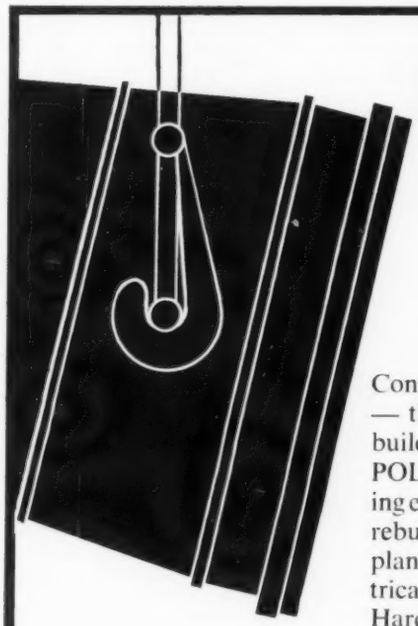
and an input connector for the thermocouple extension wire.

In addition to the portable Speedomax H instrument, a panel-mounted model—without signal lights, handle, "feet," or line cord—is also available.

TRANSFORMERS

△ Redesigned industrial power transformers, featuring less floor space, simplified up-rating, in-

(*Continued on page 260*)



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Contact POLLOCK ENGINEERING — the nation's most experienced rebuilder of mill-type cranes and trolleys. POLLOCK supplies heavy-duty hoisting equipment custom re-engineered and rebuilt to meet the requirements of your plant. All units contain late-type electrical equipment, motors and controls. Hardened gearing and wheels. Total enclosures. Cranes rebuilt by POLLOCK are fully guaranteed—and available at a fraction of the cost of original equipment.

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ENGINEERING CO., INC.
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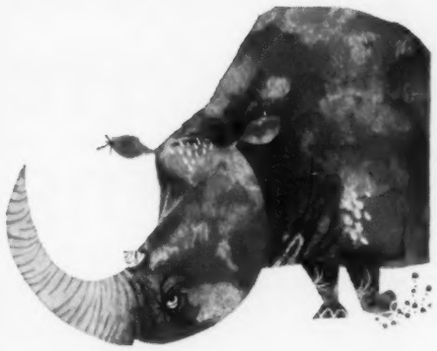

Tayco Hooks

Taylor's Tougher

Safety Superintendents and Material Handling Engineers are getting longer, safer, more maintenance-free service from TM Alloy Sling Chains. Taylor's patented Tayco Hooks are an important reason. Channel-type construction not only protects the hooker's fingers, it also adds extra strength for tougher, safer service than conventional hooks. Get all the facts! Call your distributor or write for Bulletin 14-A.

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Chain is our specialty — not our sideline!

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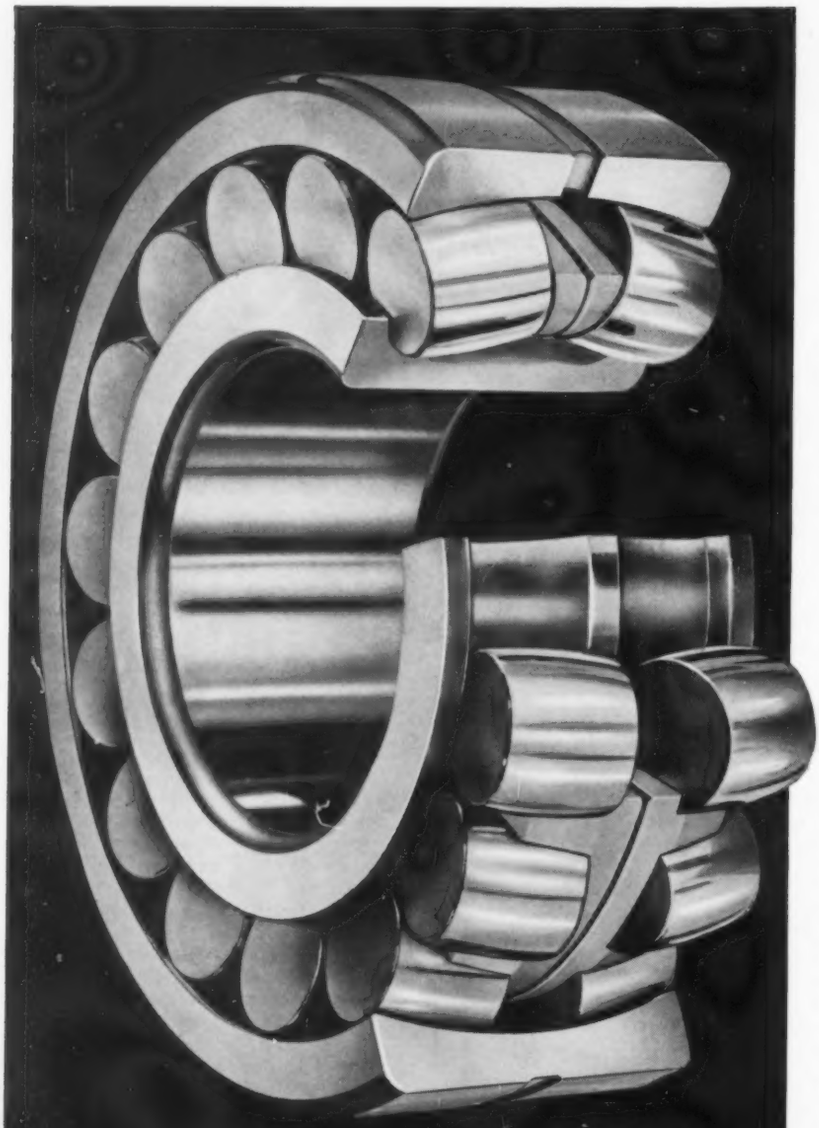
Plants: Hammond, Ind., and Pittsburgh, Pa.

LINK-BELT SPHERICAL ROLLER BEARINGS:

measure these design values in terms of your applications



GREATER CAPACITY!

The reason? *More rollers, larger rollers!* Bearing capacity depends primarily on effective roller Length, roller Diameter and Number of rollers (L x D x N). And Link-Belt offers the *largest effective roller complement* for all sizes of spherical roller bearings . . . rated according to accepted formulas of the Anti-Friction Bearing Manufacturers Association. This increase in LDN values provides extremely high capacity . . . and in users' evaluation, it adds up to far longer bearing life.

GREATER DURABILITY!

With balanced proportion design, Link-Belt spherical roller bearings possess durability characteristics that exceed the bearing industry's exacting requirements. Optimum balance of rollers, inner and outer rings must be obtained for increased bearing capacity . . . yet overall bearing dimensions must conform to an established international standard boundary plan.

Wrap-around, completely contoured retainers also contribute to durability through positive roller guidance and spacing. Precision-machined of centrifugally cast bronze, these husky retainers are far stronger than stampings or sand castings.

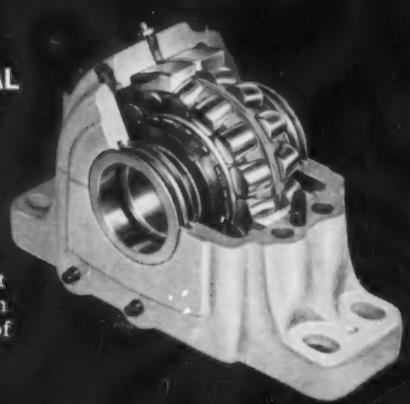
GREATER PRECISION!

Link-Belt spherical roller bearings are made in the world's most modern bearing plant . . . with the most-advanced tools and techniques known to industry. A rigid quality control program leaves *nothing* to chance. Each Link-Belt bearing is subjected to *758 actual inspections*. Microsmoothness and precision are continuously scrutinized by automatic machines. Result: these bearings have been specified by leading manufacturers of cranes, shovels, graders, vibrating screens, and steel mill, paper mill and foundry equipment . . . and for high-precision applications such as embossing rolls, printing presses and torque converters.

SEE BOOK 2760 for further precision, durability and high-capacity features. Contact your nearest Link-Belt office or authorized stock-carrying distributor. Look under BEARINGS in the Yellow Pages of your phone book.

LINK-BELT SPHERICAL ROLLER BEARING PILLOW BLOCKS

Made with sturdy gray iron or super-rugged cast-steel housings. Adapter mounting types for shafts from 1 7/16" to 10½" and direct-shaft mounting types for shafts from 1.7717" to 11.0236". Choice of rugged steel, multi-labyrinth or Dacron-contact seals.



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How this simple heat transfer process can help you

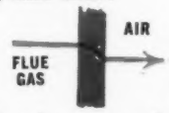
RECOVER AS MUCH AS 1,000°F FROM FLUE GAS

...and cut your fuel costs 1% for each 35°-40° F recovered

The advantages of preheating combustion air are many . . . more complete combustion . . . higher furnace temperatures . . . increased furnace capacity . . . improved product. On the basis of *fuel savings alone*, the Ljungstrom® Air Preheater should be carefully considered for many steelmaking applications since it can recover as much as 1000°F from flue gas, with savings in fuel costs of 1% for each 35°-40°F recovered. It is *the* most efficient metallic heat exchanger ever developed.

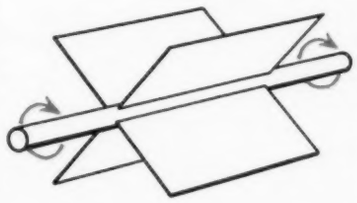
How the Ljungstrom works

Conventional recuperative preheaters are composed of tubes or plates with hot flue gas on one side and incoming air on the other, like this:

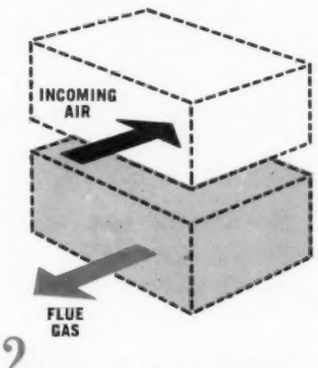


Heat must pass through the plate or tube wall. Its rate of flow depends on the heat head . . . conductivity of the metal . . . conductivity of the gas films on both sides of the metal . . . and upon the conductivity of any deposit adhering to the metal. The cumulative effect of these factors is so great that recuperative air heaters are generally quite large.

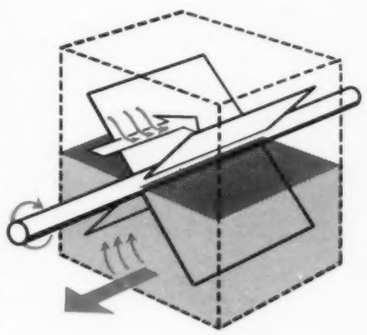
The Ljungstrom, on the other hand, is a *regenerative* air preheater. It keeps the incoming air separate from the flue gas, *but it exposes the same heating surface to both.* Heat need not pass through a film-deposit-metal-film barrier. It is simply absorbed by a heating surface, then released – from the *same* surface – to incoming air. Because of this operating principle, the Ljungstrom is remarkably compact as well as efficient. A unit measuring 5′ x 7′ x 8′, using 2000°F flue gas diluted to 1500°F, can handle a furnace exhausting 30,000,000 Btu/hr and raise incoming air from 70°F to 1400°F. The simplified sketches at the left illustrate the operating principle.



1 Basic heat transfer mechanism of the Ljungstrom is a rotor with thousands of square feet of metal heating surface. For simplicity, shown here as a paddle wheel.



2 Housing of the Ljungstrom is arranged to permit counter flow of hot flue gas and cold incoming air. Gas tight seals separate flue gas from air.



3 As rotor revolves slowly through both flue gas and air streams, heating surfaces continuously absorb heat from flue gas and release it to incoming air.

In the Ljungstrom, the rotor heating surface consists of many formed metal sheets packed in baskets to give extremely large heat transfer surface. A height of *one inch* of Ljungstrom heating surface will recover as much as *one foot* length of conventional tubular heaters.

Applications in the steel industry

Ljungstrom's can perform efficiently in many steelmaking applications: reheat furnaces, soaking pits, slab, billet and skelp furnaces. Used in series with checkers they can provide far higher and more uniform preheating than any other heat exchangers now in use.

Tested and proved under all conditions

Ljungstrom's continuous rotary regenerative principle has been performance-proved for more than 35 years in over 3500 units. The electric utility industry (highly conscious of fuel costs) has virtually standardized on Ljungstroms. *Every* major U.S. utility is Ljungstrom equipped, with some units in continuous service since 1923. Refineries, chemical process plants – even ocean liners and cargo vessels – save fuel with Ljungstroms. For more information write

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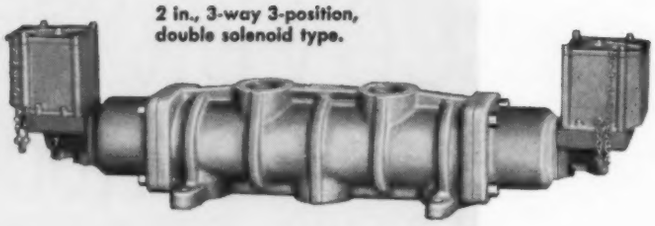
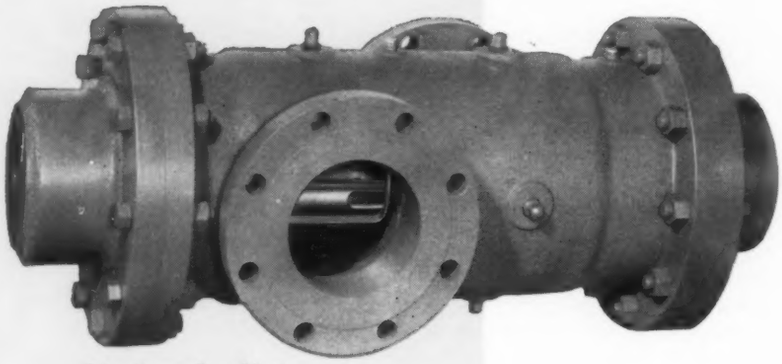
up to 8 in. • 5000 psi



2 in., 3-way 3-position, double solenoid type.



8 in., 2-way 2-position, double pilot cylinder type.

Need more flow capacity than you can get with the largest sizes available in most valve lines? There's an easier answer than resorting to costly multiple valving, or redesigning your system to suit flow limitations.

Hunt builds valves in sizes up to 8 in., with air flow ratings of *more than 32,000 cfm* @ 100 psi pressure drop! In fact, you can choose from valves ranging in size from ⅛ through 8 in.; 2 and 3-way, 4-way 2 or 3-position; solenoid, remote-pilot or mechanically actuated; with a variety of optional mountings and features.

If control of large volumes of air, oil, water, or soluble oil and water at pressures up to 5000 psi hyd. is one of your requirements, it'll pay you to talk to your Bellows-Valvair representative. His specialized knowledge can save you hours and dollars. Call him today.

3020-3

For more information, write for Bulletin 603. Address Bellows-Valvair, Pneumatics Division, Akron 9, Ohio, Dept. ISE-1261.

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Equipment News

(*Continued from page 255*)

creased capacity and reduced maintenance, have been announced by General Electric Co.

The product improvements, suggested by 32 transformer users interviewed last year, have been applied to preferred design units rated up to 25,000 kva—the rating range most frequently purchased by steel, aluminum and other large industrial plants.

Valuable floor space is conserved because the new transformers occupy at least 20 per cent less area. This improvement, plus a 20-per cent reduction in height and about a 10-per cent weight decrease, makes it easier to move and install the units, according to company engineers.

VIBRATING CONVEYOR

△ Vibrating conveyors which are operated largely by reclaiming energy created by the natural frequency vibration of coil springs, and in which conveying capacity can be varied infinitely from zero to maximum while the conveyor is in operation, have been developed by the Stephens-Adamson Mfg. Co.

Once the coil springs of the conveyor start to vibrate at their natural frequency, or resonance, they regenerate much of their own power, and only a relatively small amount of outside energy is required to keep them operating.

This additional power is supplied through a variable stroke positive eccentric drive that insures a constantly controlled amplitude of stroke and flow of material regardless of the load placed on the conveyor. Because of this variable stroke feature, the new vibrating conveyors are ideal for varying retention time in drying, cooling, dewatering or similar applications. Also, changes in conveying speed can be helpful for bagging or packaging operations, and in many instances the conveyor can be used as a feeder, thereby reducing equipment costs.

Stresses are uniformly distributed over the entire conveyor, and spring stress and flexure are kept unusually low. Lubrication is confined to drive, motor and self-alining ball bearing units minimizing maintenance.

Because the entire conveying trough goes through the same vibration cycle, there are no dead spaces and the trough or pan is self-cleaning.

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Paged 261-268 removed for ind.

IRON AND STEEL ENGINEER INDEX FOR 1961

Herewith is presented the index of all authors and papers published in the IRON AND STEEL ENGINEER for the year 1961

LIST OF AUTHORS

A

ADAMS, A. L.—"Automation in a Seamless Tube Mill," August, 1961, Page 118.
AGARWAL, DR. J. C. and SCHUERGER, T. R.—"Limitations of Blast Furnace Stoves," October, 1961, Page 143.
AGNEW, N. F.—"Steps Toward Coke Plant Automation," November, 1961, Page 107.
ANTRIM, M. B.—"The A-C Mill Motor—A New AISE Standard," November, 1961, Page 83.

B

BAILEY, C. A. and McCAA, D. R.—"Grease on Tap," May, 1961, Page 123.
BARKER, LAWRENCE S., JR., and JACOBSEN, W. B.—"Ceco's Ochiltree Works Modern Electric Furnace, Bar and Merchant Mill," December, 1961, Page 141.
BARTELS, K. D.—"Installing a Sprung Basic Open Hearth Furnace Roof," June, 1961, Page 120.
BARTHEL, ELMER E.—"Epoxy Resins Aid Steel Plant Maintenance," September, 1961, Page 129.
BAUSCHER, J. A.—"Use of Open Coil Process to Change Composition and Improve Sheet Steels," May, 1961, Page 73.
BEESWY, R. J. and McGAUGHEY, E. R.—"Inland's New Automatic Slabber," February, 1961, Page 105.
BELAN, ROMAN and DENISENKO, IVAN—"Development of USSR Iron and Steel Industry—II," December, 1961, Page 156.
BELAN, ROMAN and DENISENKO, IVAN—"Development of USSR Iron and Steel Industry," September, 1961, Page 93.
BERTRAM, J. M.—"Electric Furnaces or Cupola-Basic Oxygen Converters?" December, 1961, Page 137.
BESSENT, CARL F.—"Techniques in Rebuilding Open Hearth Furnaces," September, 1961, Page 133.
BINNS, JACK—"Super-Lathe for Roll Turning," October, 1961, Page 117.
BISCI, A. and STEPHENS, N. D.—"Automatic Gage Control on Cold Rolling Mills at DOFASCO," February, 1961, Page 93.
BJERKE, H. C.—"European Experience with the Electrically Heated Soaking Pit," April, 1961, Page 92.
BOBLITZ, WILLIAM H. and PETERSON, EDWARD C.—"Retaining Flexibility in the Design of Mechanized Merchant Bar Mills," July, 1961, Page 67.
BRADD, A. A.—"Material and Design Defects in Forged Steel Rolls," January, 1961, Page 85.
BRADDOCK, W. R.—"Orcarb Electric Furnace Process for the Direct Reduction of Iron Ore," April, 1961, Page 123.
BRANDT, W. E.—"Oxygen Lance Installation and Practice," June, 1961, Page 116.
BRITTAIN, MARSHALL and FROSTICK, H. G.—"The Blooming Mill Programmed," March, 1961, Page 99.

C

CARLSON, J. W.—"Blast Furnace Operations," May, 1961, Page 108.
CHAKKO, M. K., LATORRE, JAMES V. and SACHS, DR. GEORGE—"Roll Wear in Finishing Trains of Hot Strip Mills," December, 1961, Page 71.
CRAWFORD, C. C.—"Stretch-Reducing Operations at Colorado Fuel and Iron's Seamless Tube Mill," April, 1961, Page 77.
CRAWFORD, W. W.—"The Engineering-Purchasing Relationship," June, 1961, Page 103.

D

D'APPOLONIA, ELIO and FUGASSI, L. A.—"The Influence of Preloading on Economy of Foundations at the New Midwest Steel Mill," May, 1961, Page 111.
DAVIS, D. O.—"What's New at DOFASCO," April, 1961, Page 126.
DENISENKO, IVAN and BELAN, ROMAN—"Development of USSR Iron and Steel Industry," September, 1961, Page 93.
DENISENKO, IVAN and BELAN, ROMAN—"Development of USSR Iron and Steel Industry—II," December, 1961, Page 156.
DENNÉ, E. C.—"A Standardized Method for Rating Roller Bearing Load-Carrying Capacity," September, 1961, Page 204.
DiVINCENZO. A. P.—"Adjustable-Speed D-C Drives," March, 1961, Page 145.
DOUGLAS, W. M.—"Waste Heat Boiler Applications at Inland Steel Co.," September, 1961, Page 183.
DUFFY, J. E. and LINDBERG, V. H.—"Automated Structural Rolling Facilities at South Works of U. S. Steel," November, 1961, Page 87.

E

EL-WAZIRI, DR. A. H.—"The Transient Temperature Distribution Within Slabs Heated in Continuous Furnaces," March, 1961, Page 130.
ENDER, WILLIAM G.—"Experience with the Oxygen Analyzer-Controller," November, 1961, Page 168.
ENGLISH, ALAN—"Iron Ore Agglomeration—Sintering and Pelletizing," March, 1961, Page 113.
ESS, T. J.—"A Look at Steel in Japan," October, 1961, Page 71.
ESS, T. J.—"Armco at Butler," August, 1961, Page A-1.
ESS, T. J.—"Granite City Steel Co.," April, 1961, Page G-1.
ESS, T. J.—"Kaiser at Fontana," February, 1961, Page K-1.
EVANS, J. N. and URSCHEL, V. A.—"Gas-Fired, Radiant Comfort Heating," November, 1961, Page 130.

F

FARMER, FRED W. and MORELAND, J. C.—"Natural Gas Injection into the Blast Furnace at Lone Star Steel Co.," October, 1961, Page 88.
FEGELY, H. S.—"Data Accumulation for Metal Processing Lines," March, 1961, Page 140.
FERNANDEZ, A. and WIBLE, B. R.—"Fundidora de Fierro y Acero de Monterrey, Mexico Reports on Their New Combination Merchant Bar and Rod Mill," March, 1961, Page 89.
FREY, A. EUGENE—"The Use of Castables in Repairing Blast Furnace Linings," August, 1961, Page 120.
FRIEDLANDER, S.—"Processing Equipment for Stainless Steel Bright Annealing," May, 1961, Page 85.

FROSTICK, H. G. and BRITTAIN, MARSHALL—"The Blooming Mill Programmed," March, 1961, Page 99.
FUGASSI, L. A. and D'APPOLONIA, ELIO—"The Influence of Preloading on Economy of Foundations at the New Midwest Steel Mill," May, 1961, Page 111.

G

GAUDIO, G. M. and MADSEN, I. E.—"Coke and By-Products in 1960," December, 1961, Page 161.
GOLBEY, DONALD A.—"Applying Clear, Mill Type Pipe Coatings-Methods and Problems," September, 1961, Page 116.
GORDON, GEROME—"Conventional Batch Annealing," May, 1961, Page 71.
GREAVES, DR. M. J.—"Agglomeration of Iron Ores Furthers Automation of the Blast Furnace," March, 1961, Page 119.
GROSVENOR, GEORGE—"Colorado Fuel and Iron's Basic Oxygen Shop," July, 1961, Page 91.
GRUVER, MERLE L.—"Soaking Pit Expansion and Slabbing Mill Installation at Kaiser Steel's Fontana Plant," July 1961, Page 112.

H

HAWLEY, ROYAL and JONES, ROGER—"Trends in Rolling Mill Drive Design," September, 1961, Page 121.
HLINKA, J. W., PUHR, F. S. and PASCHKIS, DR. V.—"AISE Manual for Thermal Design of Regenerators," August, 1961, Page 59.
HOGAN, WILLIAM T., S. J.—"The Influence of Capital on Productivity," December, 1961, Page 93.
HUTCHINSON, PHILIP H.—"Why Straight Cylindrical Bearings in the Steel Industry," September, 1961, Page 196.

I

IRVIN, J. W.—"Solutions to Basic L-D Plant Layout Problems," October, 1961, Page 165.
ISLEIB, C. R.—"Ductile Iron in Steel Mills," February, 1961, Page 83.

J

JACKSON, ALBERT—"Oxygen Steelmaking in the Ajax Furnace of the Appleby-Frodingham Steel Co.," April, 1961, Page 67.
JACOBSEN, W. B. and BARKER, LAWRENCE S., JR.—"Ceco's Ochiltree Works Modern Electric Furnace, Bar and Merchant Mill," December, 1961, Page 141.
JONES, R. D. and KURZINSKI, E. F.—"Oxy-Fuel Processes Increase Steelmaking Rates," February, 1961, Page 67.
JONES, ROGER and HAWLEY, ROYAL—"Trends in Rolling Mill Drive Design," September, 1961, Page 121.

K

KENYON, ALONZO F.—"Factors Involved in the Selection of Electrical Drive Ratings for Metal Rolling Mills," November, 1961, Page 121.
KENYON, ALONZO F.—"Automatic Gage Control on Reversing Cold Strip Mills," August, 1961, Page 77.
KINSEY, C. J.—"Republic Steel Corp.'s 13-Ft Wire Mesh Facilities at Gadsden," April, 1961, Page 133.
KIRKLAND, R. W.—"Digital Computers for Accounting and Control of Continuous Processing," April, 1961, Page 138.
KOLLEK, W. E.—"Bar and Strip Mill Loopers," October, 1961, Page 125.
KOPAS, DR. JOSEPH S.—"A Training Program for Key Electrical Maintenance Employees," August, 1961, Page 89.
KRAPF, GEORGE H.—"Five-Zone Reheat Furnace—South Works," November, 1961, Page 100.
KRUMMEL, W. M.—"Integrated Automation for Steel Plants," October, 1961, Page 157.
KRUMMEL, W. M.—"Hot Strip Mill Electrical System Design Trends," May, 1961, Page 97.
KUKA, K. S.—"Stability of Steel Plant Electrical Systems," October, 1961, Page 105.
KURZINSKI, E. F. and JONES, R. D.—"Oxy-Fuel Processes Increase Steelmaking Rates," February, 1961, Page 61.

L

LAIDLAW, J. L. and WALSHAW, J. H.—"Algoma's 46-In. Blooming and Plate Mill," January, 1961, Page 67.
LATORRE, JAMES V., CHAKKO, M. K. and SACHS, DR. GEORGE—"Roll Wear in Finishing Trains of Hot Strip Mills," December, 1961, Page 71.
LIEBEL, WILLIAM R.—"Some New Design Features on a Rod and Merchant Mill," August, 1961, Page 104.
LINDBERG, V. H. and DUFFY, J. E.—"Automated Structural Rolling Facilities at South Works of U. S. Steel," November, 1961, Page 87.
LOSS, FRANK J., WEINSTEIN, DR. ALVIN S. and ZOROWSKI, DR. CARL F.—"Analytical Investigation of the Cold Rolling of Bar Stock," May, 1961, Page 135.

Mc

McCAA, D. R. and BAILEY, C. A.—"Grease on Tap," May, 1961, Page 123.
McCANDLESS, O. G.—"Some Concepts of Mill Bearing Lubrication Employing Oil, Plastic Grease and Oil Mist," September, 1961, Page 171.
McCLELLAN, H. C.—"A New Horizon in Management Planning," April, 1961, Page 148.
McGAUGHEY, E. R. and BEESWY, R. J.—"Inland's New Automatic Slabber," February, 1961, Page 105.

M

MADSEN, I. E. and GAUDIO, G. M.—"Coke and By-Products in 1960," December, 1961, Page 161.
MADSEN, I. E.—"Developments in the Iron and Steel Industry During 1960," January, 1961, Page 127.
MANLEY, H. C. and SUTCH, D. A.—"Electric Furnace or Cupola, Basic Oxygen Converter for the Nonintegrated Steel Plant," July, 1961, Page 101.
MARTHINUSS, G. L.—"D-C Differential Relay," November, 1961, Page 164.
MEISSNER, JOHN F.—"The Automatic Stockhouse," January, 1961, Page 99.
MICHALOS, G. P.—"New Inspection Techniques and Their Effect on the Mill Operator," September, 1961, Page 163.
MILLER, W. E. and SILLS, R. M.—"Automation and Process Control in the Soviet Iron and Steel Industry," June, 1961, Page 78.
MORAN, R. J. and SNIVELY, H. N.—"New Techniques in Mill Control Gives Better Hot Strip," January, 1961, Page 107.
MORELAND, J. C. and FARMER, FRED W.—"Natural Gas Injection into the Blast Furnace at Lone Star Steel Co.," October, 1961, Page 88.
MOREY, W. A.—"The Hydroelectric Crane," February, 1961, Page 99.
MYLTING, L. E.—"Pneumatic and Hydraulic Material Handling Systems in the Steel Industry," March, 1961, Page 107.

N

NELSON, D. C. and VERHEYDEN, V. E.—"New Concepts in Power-Control Rooms for Steel Mill Drive Systems," August, 1961, Page 111.
NELSON, F. D.—"Evaluation of Checker Design," October, 1961, Page 133.

O

ORAM, J. E.—"The Automated Blast Furnace—Fact or Fiction?," July, 1961, Page 119.

P

PARADIS, A. T.—"Design and Operation of Open Hearth Precipitators with Oxygen Lances," June, 1961, Page 124.
PASCHKIS, DR. V., HLINKA, J. W. and PUHR, F. S.—"AISE Manual for Thermal Design of Regenerators," August, 1961, Page 59.
PETERSON, EDWARD C. and BOBLITZ, WILLIAM H.—"Retaining Flexibility in the Design of Mechanized Merchant Bar Mills," July, 1961, Page 67.
PETRASKE, K. A. and SILLS, R. M.—"Developments in Drive Systems and Gage Control for Reversing Cold Mills," November, 1961, Page 151.
PIKE, DANIEL E. and WILLETT, HOWARD P.—"The Venturi Scrubber for Cleaning Oxygen Steel Process Gases," July, 1961, Page 126.
PORTEUS, J. H.—"What Maintenance Does the Sinter-Plant Designer Expect?," September, 1961, Page 131.
PRUDEN, W. F.—"The Story of Atlantic City," April, 1961, Page 152.
PUHR, F. S., PASCHKIS, DR. V. and HLINKA, J. W.—"AISE Manual for Thermal Design of Regenerators," August, 1961, Page 59.

R

RICKLEY, SAMUEL S. and WILSON, NORMAN A.—"Test Stand Evaluation of Oil-Film Roll Neck Bearings," September, 1961, Page 104.
ROBERTS, J. G.—"Maintenance of Electric Power Equipment," February, 1961, Page 126.
RODENBERGER, W. J.—"Lubrication of Republic Steel's 45-In. Slab Mill," March, 1961, Page 78.
ROOT, L. E.—"Life Dispersion of Anti-Friction Bearings," November, 1961, Page 113.
ROWEN, HAROLD E. and THOMPSON, C. D.—"Production Aspects of the Dwight-Lloyd McWane Ironmaking Process," June, 1961, Page 90.
RUBIN, NORBERT C.—"Analysis of Today's Tube Welding Processes," April, 1961, Page 115.

S

SACHS, DR. GEORGE, LATORRE, JAMES V. and CHAKKO, M. K.—"Roll Wear in Finishing Trains of Hot Strip Mills," December, 1961, Page 71.
SAZAVSKY, J. K.—"Automatic Control Systems for Gas Mixing Stations," January, 1961, Page 117.
SCHUERGER, T. R. and AGARWAL, DR. J. C.—"Limitations of Blast Furnace Stoves," October, 1961, Page 143.
SCHWABE, W. E.—"Fundamentals of Heat Distribution and Refractory Wear in Electric Steel Furnaces," December, 1961, Page 104.
SENIOR, A. GORDON—"New Methods of Mounting Crane Rails on Overhead Runways," July, 1961, Page 132.
SHATTUCK, A. D.—"Pressurization of Idle Coke Ovens," March, 1961, Page 83.

SHINGLEDECKER, C. W.—"Minimizing Pollution from Pickling Lines: Automatic Control of Strip Pickling Bath Composition," November, 1961, Page 137.
SILLS, R. M. and MILLER, W. E.—"Automation and Process Control in the Soviet Iron and Steel Industry," June, 1961, Page 78.
SILLS, R. M. and PETRASKE, K. A.—"Developments in Drive Systems and Gage Control for Reversing Cold Mills," November, 1961, Page 151.
SMITH, CHARLES H.—"Heating and Ventilating a Modern Steel Mill Building," June, 1961, Page 105.
SNIVELY, H. N. and MORAN, R. J.—"New Techniques in Mill Control Gives Better Hot Strip," January, 1961, Page 107.
SOARES E SILVA, GENERAL EDMUNDO DE MACEDO—"Steel Production in Latin American Countries," March, 1961, Page 65.
SONNENFELDT, R. W.—"Computers for Industrial Control," August, 1961, Page 96.
SOROKIN, V. O.—"Design and Operation of Tensiometers," May, 1961, Page 130.
SOUTHERINGTON, C. W.—"Oil Mist Lubrication on Anti-Friction Backup Roll Bearings," December, 1961, Page 121.
SPRAY, W. N.—"The Next Step in Steel Plant Data Processing," December, 1961, Page 113.
SPROWL, JOHN D.—"The Production and Uses of Aluminized Steel," October, 1961, Page 96.
STEINHEIDER, WILT H.—"Cupola Metal Increases Open Hearth Production," July, 1961, Page 108.
STEPHENS, N. D. and BISCI, A.—"Automatic Gage Control on Cold Rolling Mills at DOFASCO," February, 1961, Page 93.
STEWART, DONALD, JR.—"The Power Distribution System of an Integrated Steel Plant," December, 1961, Page 150.
STONE, MORRIS D.—"The Rolling of Ultra-Thin Tin Plate," June, 1961, Page 67.
STOVER, W. L.—"Recent Developments in Rolling Mill Equipment," November, 1961, Page 158.
STRAUSS, W.—"Dealing with Fumes from the Open Hearth," June, 1961, Page 98.
SUTCH, D. A. and MANLEY, H. C.—"Electric Furnace or Cupola, Basic Oxygen Converter for the Nonintegrated Steel Plant," July, 1961, Page 101.

T

TAYLOR, H. E.—"Elimination of a Coke Plant Relief Holder," December, 1961, Page 97.
THOMPSON, C. D. and ROWEN, HAROLD E.—"Production Aspects of the Dwight-Lloyd McWane Ironmaking Process," June, 1961, Page 90.
TRENNER, J. F.—"Safety for Steel Plant Electrical Men," September, 1961, Page 144.

U

URANO, A. S.—"The Application of Rectifiers for Processing and Auxiliary Drives," September, 1961, Page 177.
URSCHEL, V. A. and EVANS, J. N.—"Gas-Fired, Radiant Comfort Heating," November, 1961, Page 130.

V

VARNER, D. E.—"Automatic Gage Control as a Function of Transport Distance," September, 1961, Page 188.
VERHEYDEN, V. E. and NELSON, D. C.—"New Concepts in Power-Control Rooms for Steel Mill Drive Systems," August, 1961, Page 111.
VOGT, WILLIAM A.—"Open Hearth Improvements for Optimum Results Using Oxy-Fuel Burners and Oxygen Lances," June, 1961, Page 87.
VONADA, E. E.—"Electrochemistry in the Steel Industry," December, 1961, Page 131.

W

WALSHAW, J. H. and LAIDLAW, J. L.—"Algoma's 46-In. Blooming and Plate Mill," January, 1961, Page 67.
WEINSTEIN, DR. ALVIN, S., ZOROWSKI, DR. CARL F. and LOSS, FRANK J.—"Analytical Investigation of the Cold Rolling of Bar Stock," May, 1961, Page 135.
WEINSTEIN, ALVIN S. and ZOROWSKI, CARL F.—"An Analysis of the Stresses and Deformations in Work Rolls," April, 1961, Page 99.
WETTACH, J. PHILIP—"The Design of Coolant Systems as Affected by Various Cold Rolled Products," November, 1961, Page 144.
WIBLE, B. R. and FERNANDEZ, A.—"Fundidora de Fierro y Acero de Monterrey, Mexico Reports on Their New Combination Merchant Bar and Rod Mill," March, 1961, Page 89.
WICOFF, J. R.—"Reduction of Maintenance Through Modern Lubricants," April, 1961, Page 121.
WILLENBROCK, H. C., JR.—"Refractory Maintenance in Basic Oxygen Steelmaking Process," March, 1961, Page 75.
WILLETT, HOWARD P. and PIKE, DANIEL E.—"The Venturi Scrubber for Cleaning Oxygen Steel Process Gases," July, 1961, Page 126.
WILSON, NORMAN A. and RICKLEY, SAMUEL S.—"Test Stand Evaluation of Oil-Film Roll Neck Bearings," September, 1961, Page 104.
WINCHESTER, A. J.—"How to Get and Use Rolling Mill Power Data," July, 1961, Page 92.
WOLFE, F. J., JR.—"Development of a Machine Shop Tool Program," March, 1961, Page 125.
WOODBURY, F. A.—"Selecting Electrical Drives for Applications Under 500 HP," April, 1961, Page 85.

Y

YOUNG, JOHN L.—"Observations of the Steel Industry in India and Japan," January, 1961. Page 61.

Z

ZOLKOWSKI, W. Z.—"Spring-Loaded Rod Checks Blast Furnace Voids," November, 1961, Page 162.
ZOROWSKI, DR. CARL F., LOSS, FRANK J. and WEINSTEIN, DR. ALVIN S.—"Analytical Investigation of the Cold Rolling of Bar Stock," May, 1961, Page 135.
ZOROWSKI, CARL F. and WEINSTEIN, ALVIN S.—"An Analysis of the Stresses and Deformations in Work Rolls," April, 1961, Page 99.

LIST OF SUBJECTS

A

"Abstracts of Technical Papers to be Presented at Technical Sessions of AISE Annual Convention," September, 1961, Page 151.
"Abstracts of Technical Papers to be Presented at AISE Spring Conference Program," April, 1961, Page 108.
"Abstracts of Technical Papers to be Presented at AISE Western Meeting," February, 1961, Page 76.
"A-C Mill Motor—A New AISE Standard, The"—By M. B. ANTRIM, November, 1961, Page 83.
"A-C Mill Motor Standards (Tentative), AISE Standard No. 1-A," November, 1961, Page 79.
"Adjustable-Speed D-C Drives"—By A. P. DiVINCENZO, March, 1961, Page 145.
"AISE Annual Convention, Abstracts of Technical Papers to be presented at Technical Sessions of," September, 1961, Page 151.
"AISE Annual Convention, Pictorial Review," October, 1961, Page 162.
"AISE Annual Convention, Program—1961," September, 1961, Page 148.
"AISE District Section Meeting Notices, Current," November, 1961, Page 120.
"AISE District Section Meeting Notices, Current," October, 1961, Page 104.
"AISE District Section Meeting Notices, Current," April, 1961, Page 120.
"AISE District Section Meeting Notices, Current," March, 1961, Page 88.
"AISE District Section Meeting Notices, Current," February, 1961, Page 82.
"AISE District Section Meeting Notices, Current," January, 1961, Page 180.
"AISE District Section Summer Meeting Notices," May, 1961, Page 105.
"AISE Manual for Thermal Design of Regenerators"—By J. W. HLINKA, F. S. PUHR and DR. V. PASCHKIS, August, 1961, Page 59.
"AISE National Committees, 1961," January, 1961, Page 83.
"AISE Officers and Directors, 1961," January, 1961, Page 80.
"AISE Standard No. 1-A—A-C Mill Motor Standards (Tentative)," November, 1961, Page 79.
"AISE Spring Conference, Program," March, 1961, Page 97.
"AISE Spring Conference Program, Abstracts of Technical Papers to be Presented at," April, 1961, Page 108.
"AISE Western Meeting, Abstracts of Technical Papers to be Presented at," February, 1961, Page 76.
"AISE Western Meeting, Program," February, 1961, Page 74.
"AISE Western Meeting, Pictorial Roundup," April, 1961, Page 146.
"Agglomeration of Iron Ores Furthers Automation of the Blast Furnace"—By DR. M. J. GREAVES, March, 1961, Page 119.
"Ajax Furnace of the Appleby-Frodingham Steel Co., Oxygen Steelmaking in the"—By ALBERT JACKSON, April, 1961, Page 67.
"Algoma's 46-In. Blooming and Plate Mill"—By J. L. LAIDLAW and J. H. WALSHAW, January, 1961, Page 67.
"Aluminized Steel, The Production and Uses of"—By JOHN D. SPROWL, October, 1961, Page 96.
"Analysis of the Stresses and Deformations in Work Rolls, An"—By CARL F. ZOROWSKI and ALVIN S. WEINSTEIN, April, 1961, Page 99.
"Analysis of Today's Tube Welding Processes"—By NORBERT C. RUBIN, April, 1961, Page 115.
"Analytical Investigation of the Cold Rolling of Bar Stock"—By DR. ALVIN S. WEINSTEIN, DR. CARL F. ZOROWSKI and FRANK J. LOSS, May, 1961, Page 135.
"Analyzer-Controller, Experience with the Oxygen,"—By WILLIAM G. ENDER, November, 1961, Page 168.
"Annealing, Conventional Batch,"—By GEROME GORDON, May, 1961, Page 71.
"Annealing, Processing Equipment for Stainless Steel Bright"—By S. FRIEDLANDER, May, 1961, Page 85.
"Anti-Friction Backup Roll Bearings, Oil Mist Lubrication on"—By C. W. SOUTHERINGTON, December, 1961, Page 121.
"Appleby-Frodingham Steel Co., Oxygen Steelmaking in the Ajax Furnace of the"—By ALBERT JACKSON, April, 1961, Page 67.

"Application of Rectifiers for Processing and Auxiliary Drives, The"—By A. S. URANO, September, 1961, Page 177.
"Applying Clear Mill Type Pipe Coatings—Methods and Problems"—By DONALD A. GOLBEY, September, 1961, Page 116.
"Armco at Butler"—By T. J. ESS, August, 1961, Page A-1.
"Atlantic City, The Story of"—By W. F. PRUDEN, April, 1961, Page 152.
"Automated Blast Furnace—Fact or Fiction? The"—By J. E. ORAM, July, 1961, Page 119.
"Automated Structural Rolling Facilities at South Works of U. S. Steel"—By V. H. LINDBERG and J. E. DUFFY, November, 1961, Page 87.
"Automatic Control Systems for Gas Mixing Stations"—By J. K. SAZAVSKY, January, 1961, Page 117.
"Automatic Gage Control as a Function of Transport Distance"—By D. E. VARNER, September, 1961, Page 188.
"Automatic Gage Control on Cold Rolling Mills at DOFASCO"—By N. D. STEPHENS and A. BISCI, February, 1961, Page 93.
"Automatic Gage Control on Reversing Cold Strip Mills"—By ALFONZO F. KENYON, August, 1961, Page 77.
"Automatic Stockhouse, The"—By JOHN F. MEISSNER, January, 1961, Page 99.
"Automation and Prccess Control in the Soviet Iron and Steel Industry"—By W. E. MILLER and R. M. SILLS, June, 1961, Page 78.
"Automation for Steel Plants, Integrated"—By W. M. KRUMMEL, October, 1961, Page 157.
"Automation in a Seamless Tube Mill"—By A. L. ADAMS, August, 1961, Page 118.
"Automation for the Casting Shop"—By H. HENRY SINASON, May, 1961, Page 92.
"Automation, Steps Toward Coke Plant"—By N. F. AGNEW, November, 1961, Page 107.
"Award Won by J. S. Ride, 1960 AISE Papers"—October, 1961, Page 164.

B

"Bar and Strip Mill Loopers"—By W. E. KOLLEK, October, 1961, Page 125.
"Bar Mills, Retaining Flexibility to the Design of Mechanized Merchant"—By EDWARD C. PETERSON and WILLIAM H. BOBLITZ, July, 1961, Page 67.
"Bar Stock, Analytical Investigation of the Cold Rolling of"—By DR. ALVIN S. WEINSTEIN, DR. CARL F. ZOROWSKI and FRANK J. LOSS, May, 1961, Page 135.
"Bearing Load-Carrying Capacity, A Standardized Method for Rating Roller"—By E. C. DENNÉ, September, 1961, Page 204.
"Bearing Lubrication Employing Oil, Plastic Grease and Oil Mist, Some Concepts of Mill"—By O. G. McCANDLESS, September, 1961, Page 171.
"Bearings in the Steel Industry, Why Straight Cylindrical"—By PHILIP H. HUTCHINSON, September, 1961, Page 196.
"Bearings, Life Dispersion of Anti-Friction"—By L. E. ROOT, November, 1961, Page 113.
"Bearings, Oil Mist Lubrication on Anti-Friction Backup Roll"—By C. W. SOUTHERINGTON, December, 1961, Page 121.
"Bearing, Test Stand Evaluation of Oil-Film Roll Neck"—By SAMUEL S. RICKLEY and NORMAN A. WILSON, September, 1961, Page 104.
"Blast Furnace, Agglomeration of Iron Ores Furthers Automation of the"—By DR. M. J. GREAVES, March, 1961, Page 119.
"Blast Furnace at Lone Star Steel Co., Natural Gas Injection into the"—By FRED W. FARMER and J. C. MORELAND, October, 1961, Page 88.
"Blast Furnace—Fact or Fiction? The Automated"—By J. E. ORAM, July, 1961, Page 119.
"Blast Furnace Operations"—By J. W. CARLSON, May, 1961, Page 108.
"Blast Furnace Stoves, Limitations of"—By T. R. SCHUERGER and DR. J. C. AGARWAL, October, 1961, Page 143.
"Blast Furnace Voids, Spring-Loaded Rod Checks"—By W. Z. ZOLKOWSKI, November, 1961, Page 162.
"Blooming and Plate Mill, Algoma's 46-In."—By J. L. LAIDLAW and J. H. WALSHAW, January, 1961, Page 67.
"Blooming Mill Programmed, The"—By MARSHALL BRITTAIN and H. G. FROSTICK, March, 1961, Page 99.
"Boiler Applications at Inland Steel Co., Waste Heat"—By W. M. DOUGLAS, September, 1961, Page 183.
"Butler, Armco at"—By T. J. ESS, August, 1961, Page A-1.

C

"Capital on Productivity, The Influence of"—By WILLIAM T. HOGAN, S. J., December, 1961, Page 93.
"Castables in Repairing Blast Furnace Linings, The Use of"—By A. EUGENE FREY, August, 1961, Page 120.
"Casting Shop, Automation for the,"—By H. HENRY SINASON, May, 1961, Page 92.
"Ceco's Ochiltree Works Modern Electric Furnace, Bar and Merchant Mill"—By W. B. JACOBSEN and LAWRENCE S. BARKER, JR., December, 1961, Page 141.
"Checker Design, Evaluation of"—By F. D. NELSON, October, 1961, Page 133.
"Coatings—Methods and Problems, Applying Clear, Mill Type Pipe"—By DONALD A. GOLBEY, September, 1961, Page 116.
"Coil Process to Change Composition and Improve Sheet Steels, Use of Open"—By J. A. BAUSCHER, May, 1961, Page 73.
"Coke and By-Products in 1960"—By G. M. GAUDIO and I. E. MADSEN, December, 1961, Page 161.
"Coke Ovens, Pressurization of Idle"—By A. D. SHATTUCK, March, 1961, Page 83.
"Coke Plant Automation, Steps Toward"—By N. F. AGNEW, November, 1961, Page 107.
"Coke Plant Relief Holder, Elimination of A"—By H. E. TAYLOR, December, 1961, Page 97.
"Cold Mills, Developments in Drive Systems and Gage Control for Reversing"—By K. A. PETRASKE and R. M. SILLS, November, 1961, Page 151.
"Cold Rolled Products, The Design of Coolant Systems as Affected by Various"—By J. PHILIP WETTACH, November, 1961, Page 144.
"Cold Rolling of Bar Stock, Analytical Investigation of the"—By DR. ALVIN S. WEINSTEIN, DR. CARL F. ZOROWSKI and FRANK J. LOSS, May, 1961, Page 135.
"Cold Strip Mills, Automatic Gage Control on Reversing"—By ALONZO F. KENYON, August, 1961, Page 77.
"Colorado Fuel and Iron's Basic Oxygen Shop"—By GEORGE GROSVENOR, July, 1961, Page 91.
"Colorado Fuel and Iron's Seamless Tube Mill, Stretch-Reducing Operations at"—By C. C. CRAWFORD, April, 1961, Page 77.
"Computers for Accounting and Control of Continuous Processing Lines, Digital"—By R. W. KIRKLAND, April, 1961, Page 138.
"Computers for Industrial Control"—By R. W. SONNENFELDT, August, 1961, Page 96.
"Control, Computers for Industrial"—By R. W. SONNENFELDT, August, 1961, Page 96.
"Control Gives Better Hot Strip, New Techniques in Mill"—By R. J. MORAN and H. N. SNIVELY, January, 1961, Page 107.
"Control Systems for Gas Mixing Stations, Automatic"—By J. K. SAZAVSKY, January, 1961, Page 117.
"Convention, Abstracts of Technical Papers to be Presented at Technica Sessions of AISE Annual," September, 1961, Page 151.
"Convention, Pictorial Review—AISE Annual," October, 1961, Page 162.
"Convention, Program—1961 AISE Annual," August, 1961, Page 107.
"Conventional Batch Annealing"—By GEROME GORDON, May, 1961, Page 71.
"Converter for the Nonintegrated Steel Plant, Electric Furnace or Cupola, Basic Oxygen"—By D. A. SUTCH and H. C. MANLEY, July, 1961, Page 101.
"Converters? Electric Furnaces or Cupola-Basic Oxygen"—By J. M. BERTRAM, December, 1961, Page 137.
"Coolant Systems as Affected by Various Cold Rolled Products, The Design of"—By J. PHILIP WETTACH, November, 1961, Page 144.
"Crane Rails on Overhead Runways, New Methods of Mounting"—By A. GORDON SENIOR, July, 1961, Page 132.
"Crane, The Hydroelectric"—By W. A. MOREY, February, 1961, Page 99.
"Cupola, Basic Oxygen Converter for the Nonintegrated Steel Plant, Electric Furnace or"—By D. A. SUTCH and H. C. MANLEY, July, 1961, Page 101.
"Cupola-Basic Oxygen Converters? Electric Furnaces or"—By J. M. BERTRAM, December, 1961, Page 137.
"Cupola Metal Increases Open Hearth Production"—By WILT H. STEINHEIDER, July, 1961, Page 108.
"Current AISE District Section Meeting Notices," December, 1961, Page 140.
"Current AISE District Section Meeting Notices," November, 1961, Page 120.
"Current AISE District Section Meeting Notices," October, 1961, Page 104.
"Current AISE District Section Meeting Notices," September, 1961, Page 213.
"Current AISE District Section Meeting Notices," August, 1961, Page 95.
"Current AISE District Section Meeting Notices," April, 1961, Page 120.
"Current AISE District Section Meeting Notices," March, 1961, Page 88.
"Current AISE District Section Meeting Notices," February, 1961, Page 82.
"Current AISE District Section Meeting Notices," January, 1961, Page 180.
"Cylindrical Bearings in the Steel Industry, Why Straight"—By PHILIP H. HUTCHINSON, September, 1961, Page 196.

D

"Data Accumulation for Metal Processing Lines"—By H. S. FEGELY, March, 1961, Page 140.
"Data Processing, The Next Step in Steel Plant"—By W. N. SPRAY, December, 1961, Page 113.
"D-C Differential Relay"—By G. L. MARTHINUSS, November, 1961, Page 164.
"Dealing with Fumes from the Open Hearth"—By W. STRAUSS, June, 1961, Page 98.
"Defects in Forged Steel Rolls, Material and Design"—By A. A. BRADD, January, 1961, Page 85.
"Design and Operation of Open Hearth Precipitators with Oxygen Lances"—By A. T. PARADIS, June, 1961, Page 124.
"Design and Operation of Tensiometers"—By V. O. SOROKIN, May, 1961, Page 130.
"Design Features on a Rod and Merchant Mill, Some New"—By WILLIAM R. LIEBEL, August, 1961, Page 104.
"Design of Coolant Systems as Affected by Various Cold Rolled Products, The"—By J. PHILIP WETTACH, November, 1961, Page 144.

"Development of a Machine Shop Tool Program"—By F. J. WOLFE, JR., March, 1961, Page 125.
"Development of USSR Iron and Steel Industry"—By IVAN DENISENKO and ROMAN BELAN, September, 1961, Page 93.
"Development of USSR Iron and Steel Industry—II," By IVAN DENISENKO and ROMAN BELAN, December, 1961, Page 156.
"Developments in Drive Systems and Gage Control for Reversing Cold Mills"—By K. A. PETRASKE and R. M. SILLS, November, 1961, Page 151.
"Developments in the Iron and Steel Industry During 1960"—By I. E. MADSEN, January, 1960, Page 127.
"Digital Computers for Accounting and Control of Continuous Processing Lines"—By R. W. KIRKLAND, April, 1961, Page 138.
"Direct Reduction of Iron Ore, Orcarb Electric Furnace Process for the"—By W. R. BRADDOCK, April, 1961, Page 123.
"Distribution System of an Integrated Steel Plant, The Power"—By DONALD STEWART, JR., December, 1961, Page 150.
"DOFASCO, Automatic Gage Control on Cold Rolling Mills at"—By N. D. STEPHENS and A. BISCI, February, 1961, Page 93.
"DOFASCO, What's New at"—By D. O. DAVIS, April, 1961, Page 126.
"Drive Design, Trends in Rolling Mill"—By ROGER JONES and ROYAL HAWLEY, September, 1961, Page 121.
"Drive Ratings for Metal Rolling Mills, Factors Involved in the Selection of Electrical"—By ALONZO F. KENYON, November, 1961, Page 121.
"Drive Systems and Gage Control for Reversing Cold Mills, Developments in"—By K. A. PETRASKE and R. M. SILLS, November, 1961, Page 151.
"Drive Systems, New Concepts in Power-Control Rooms for Steel Mill"—By V. E. VERHEYDEN and D. C. NELSON, August, 1961, Page 111.
"Drives, Adjustable-Speed D-C"—By A. P. DiVINCENZO, March, 1961, Page 145.
"Drives for Applications Under 500 HP, Selecting"—By F. A. WOODBURY, April, 1961, Page 85.
"Drives, The Application of Rectifiers for Processing and Auxiliary"—By A. S. URANO, September, 1961, Page 177.
"Ductile Iron in Steel Mills"—By C. R. ISLEIB, February, 1961, Page 83.
"Dwight-Lloyd McWane Ironmaking Process, Production Aspects of the"—By HAROLD E. ROWEN and C. D. THOMPSON, June, 1961, Page 90.

E

"Electric Furnace, Bar and Merchant Mill, Ceco's Ochiltree Works Modern"—By W. B. JACOBSEN and LAWRENCE S. BARKER, JR., December, 1961, Page 141.
"Electric Furnace or Cupola, Basic Oxygen Converter for the Nonintegrated Steel Plant"—By D. A. SUTCH and H. C. MANLEY, July, 1961, Page 101.
"Electric Furnace Process for the Direct Reduction of Iron Ore, Orcarb"—By W. R. BRADDOCK, April, 1961, Page 123.
"Electric Furnaces or Cupola-Basic Oxygen Converters?"—By J. M. BERTRAM, December, 1961, Page 137.
"Electric Power Equipment, Maintenance"—By J. G. ROBERTS, February, 1961, Page 126.
"Electric Steel Furnaces, Fundamentals of Heat Distribution and Refractory Wear in"—By W. E. SCHWABE, December, 1961, Page 104.
"Electrical Drive Ratings for Metal Rolling Mills, Factors Involved in the Selection of"—By ALONZO F. KENYON, November, 1961, Page 121.
"Electrical Maintenance Employees, A Training Program for Key"—By DR. JOSEPH S. KOPAS, August, 1961, Page 89.
"Electrical Men, Safety for Steel Plant"—By J. F. TRENNER, September, 1961, Page 144.
"Electrical System Design Trends, Hot Strip Mill"—By W. M. KRUMMEL, May, 1961, Page 97.
"Electrical Systems, Stability of Steel Plant"—By K. S. KUKA, October, 1961, Page 105.
"Electrically Heated Soaking Pit, European Experience with the"—By H. C. BJERKE, April, 1961, Page 92.
"Electrochemistry in the Steel Industry"—By E. E. VONADA, December, 1961, Page 131.
"Elimination of Coke Plant Relief Holder"—By H. E. TAYLOR, December, 1961, Page 97.
"Engineering-Purchasing Relationship, The"—By W. W. CRAWFORD, June, 1961, Page 103.
"Epoxy Resins Aid Steel Plant Maintenance"—By ELMER E. BARTHEL, September, 1961, Page 129.
"European Experience with the Electrically Heated Soaking Pit"—By H. C. BJERKE, April, 1961, Page 92.
"Evaluation of Checker Design"—By F. D. NELSON, October, 1961, Page 133.
"Experience with the Oxygen Analyzer-Controller"—By WILLIAM G. ENDER, November, 1961, Page 168.

F

"Factors Involved in the Selection of Electrical Drive Ratings for Metal Rolling Mills"—By ALONZO F. KENYON, November, 1961, Page 121.
"Fairless Works Open Hearth Shop, Symposium on"—By W. E. BRANDT, K. D. BARTELS and A. T. PARADIS, June, 1961, Page 116.
"Finishing Trains of Hot Strip Mills, Roll Wear in"—By DR. GEORGE SACHS, JAMES V. LATORRE and M. K. CHAKKO, December, 1961, Page 71.
"Five-Zone Reheat Furnace—South Works"—By GEORGE H. KRAPF, November, 1961, Page 100.
"Fontana, Kaiser at"—By T. J. ESS, February, 1961, Page K-1.
"Fumes from the Open Hearth, Dealing with"—By W. STRAUSS, June, 1961, Page 98.
"Fundamentals of Heat Distribution and Refractory Wear in Electric Steel Furnaces"—By W. E. SCHWABE, December, 1961, Page 104.
"Fundidora de Fierro y Acero de Monterrey, Mexico Reports on Their New Combination Merchant Bar and Rod Mill"—By A. FERNANDEZ and B. R. WIBLE, March, 1961, Page 89.
"Furnace at Lone Star Steel Co., Natural Gas Injection into the Blast"—By FRED W. FARMER and J. C. MORELAND, October, 1961, Page 88.
"Furnace, Ceco' sOchiltree Works Modern Electric, Bar and Merchant Mill"—By W. B. JACOBSEN and LAWRENCE S. BARKER, JR., December, 1961, Page 141.
"Furnace Linings, The Use of Castables in Repairing Blast"—By A. EUGENE FREY, August, 1961, Page 120.
"Furnace Operations, Blast"—By J. W. CARLSON, May, 1961, Page 108.
"Furnace—South Works, Five-Zone Reheat"—By GEORGE H. KRAPF, November, 1961, Page 100.
"Furnace Voids, Spring-Loaded Rod Checks Blast"—By W. Z. ZOLKOWSKI, November, 1961, Page 162.
"Furnaces, Fundamentals of Heat Distribution and Refractory Wear in Electric Steel"—By W. E. SCHWABE, December, 1961, Page 104.
"Furnaces, The Transient Temperature Distribution Within Slabs Heated in Continuous Furnaces"—By DR. A. H. EL-WAZIRI, March, 1961, Page 130.

G

"Gadsden, Republic Steel Corp.'s 13-Ft Wire Mesh Facilities at"—By C. J. KINSEY, April, 1961, Page 133.
"Gage Control as a Function of Transport Distance, Automatic"—By D. E. VARNER, September, 1961, Page 188.
"Gage Control for Reversing Cold Mills, Developments in Drive Systems and"—By K. A. PETRASKE and R. M. SILLS, November, 1961, Page 151.
"Gage Control on Cold Rolling Mills at DOFASCO, Automatic"—By N. D. STEPHENS and A. BISCI, February, 1961, Page 93.
"Gage Control on Reversing Cold Strip Mills, Automatic"—By ALONZO F. KENYON, August, 1961, Page 77.
"Gas-Fired, Radiant Comfort Heating"—By J. N. EVANS and V. A. URSCHEL, November, 1961, Page 130.
"Gas Injection into the Blast Furnace at Lone Star Steel Co., Natural"—By FRED W. FARMER and J. C. MORELAND, October, 1961, Page 88.
"Gas Mixing Stations, Automatic Control Systems for"—By J. K. SAZAVSKY, January, 1961, Page 117.
"Gases, The Venturi Scrubber for Cleaning Oxygen Steel Process"—By HOWARD P. WILLETT and DANIEL E. PIKE, July, 1961, Page 126.
"Granite City Steel Co."—By T. J. ESS, April, 1961, Page G-1.
"Grease on Tap"—By C. A. BAILEY and D. R. McCAA, May, 1961, Page 123.

H

"Handling Systems in the Steel Industry, Pneumatic and Hydraulic Material"—By L. E. MYLTING, March, 1961, Page 107.
"Hearth Furnace Roof, Installing a Sprung Basic Open"—By K. D. BARTELS, June, 1961, Page 120.
"Heat Distribution and Refractory Wear in Electric Steel Furnaces, Fundamentals of"—By W. E. SCHWABE, December, 1961, Page 104.
"Heating and Ventilating a Modern Steel Mill Building"—By CHARLES H. SMITH, June, 1961, Page 105.
"Holder, Elimination of a Coke Plant Relief"—By H. E. TAYLOR, December, 1961, Page 97.
"Hot Strip Mill Electrical System Design Trends"—By W. M. KRUMMEL, May, 1961, Page 97.
"How to Get and Use Rolling Mill Power Data"—By A. J. WINCHESTER, July, 1961, Page 92.
"Hydraulic Material Handling Systems in the Steel Industry, Pneumatic and"—By L. E. MYLTING, March, 1961, Page 107.
"Hydroelectric Crane, The"—By W. A. MOREY, February, 1961, Page 99.

I

"India and Japan, Observations of the Steel Industry in"—By JOHN L. YOUNG, January, 1961, Page 61.
"Influence of Capital on Productivity, The"—By WILLIAM T. HOGAN, S. J., December, 1961, Page 93.
"Influence of Preloading on Economy of Foundations at the New Midwest Steel Mill, The"—By ELIO D'APPOLONIA and L. A. FUGASSI, May, 1961, Page 111.
"Inland Steel Co., Waste Heat Boiler Applications at"—By W. M. DOUGLAS, September, 1961, Page 183.
"Inland's New Automatic Slabber"—By E. R. McGAUGHEY and R. J BEESWY, February, 1961, Page 105.
"Inspection Techniques and Their Effect on the Mill Operator, New"—By G. P. MICHALOS, September, 1961, Page 163.
"Installing a Sprung Basic Open Hearth Furnace Roof"—By K. D. BARTELS, June, 1961, Page 120.
"Integrated Automation for Steel Plants"—By W. M. KRUMMEL, October, 1961, Page 157.

"Integrated Steel Plant, The Power Distribution System of an"—By DONALD STEWART, JR., December, 1961, Page 150.
"Iron in Steel Mills, Ductile"—By C. R. ISLEIB, February, 1961, Page 83.
"Ironmaking Process, Production Aspects of the Dwight-Lloyd McWane"—By HAROLD E. ROWEN and C. D. THOMPSON, June, 1961, Page 90.
"Iron Ore Agglomeration—Sintering and Pelletizing"—By ALAN ENGLISH, March, 1961, Page 113.

J

"Japan, A Look at Steel in"—By T. J. ESS, October, 1961, Page 71.
"Japan, Observations of the Steel Industry in India and"—By JOHN L. YOUNG, January, 1961, Page 61.

K

"Kaiser at Fontana"—By T. J. ESS, February, 1961, Page K-1.
"Kaiser Steel's Fontana Plant, Soaking Pit Expansion and Slabbing Mill Installation at"—By MERLE L. GRUVER, July, 1961, Page 112.

L

"Lance Installation and Practice, Oxygen"—By W. E. BRANDT, June, 1961, Page 116.
"Latin American Countries, Steel Production in"—By GENERAL EDMUNDO DE MACEDO SOARES E SILVA, March, 1961, Page 65.
"L-D Plant Layout Problems, Solutions to Basic"—By J. W. IRVIN, October, 1961, Page 165.
"Life Dispersion of Anti-Friction Bearings"—By L. E. ROOT, November, 1961, Page 113.
"Limitations of Blast Furnace Stoves"—By T. R. SCHUERGER and DR. J. C. AGARWAL, October, 1961, Page 143.
"Linings, The Use of Castables in Repairing Blast Furnace"—By A. EUGENE FREY, August, 1961, Page 120.
"Lone Star Steel Co., Natural Gas Injection into the Blast Furnace at"—By FRED W. FARMER and J. C. MORELAND, October, 1961, Page 88.
"Look at Steel in Japan, A"—By T. J. ESS, October, 1961, Page 71.
"Loopers, Bar and Strip Mill"—By W. E. KOLLEK, October, 1961, Page 125.
"Lubricants, Reduction of Maintenance Through Modern"—By J. R. WICOFF, April, 1961, Page 121.
"Lubrication Employing Oil, Plastic Grease and Oil Mist, Some Concepts of Mill Bearing"—By O. G. McCANDLESS, September, 1961, Page 171.
"Lubrication of Republic Steel's 45-In. Slab Mill"—By W. J. RODENBERGER, March, 1961, Page 78.
"Lubrication on Anti-Friction Backup Roll Bearings, Oil Mist"—By C. W. SOUTHERINGTON, December, 1961, Page 121.

M

"Maintenance Does the Sinter-Plant Designer Expect? What"—By J. H. PORTEUS, September, 1961, Page 131.
"Maintenance Employees, A Training Program for Key Electrical"—By DR. JOSEPH S. KOPAS, August, 1961, Page 89.
"Maintenance, Epoxy Resins Aid Steel Plant"—By ELMER E. BARTHEL, September, 1961, Page 129.
"Maintenance in Basic Oxygen Steelmaking Process, Refractory"—By H. C. WILLENBROCK, JR., March, 1961, Page 75.
"Maintenance of Electric Power Equipment"—By J. G. ROBERTS, February, 1961, Page 126.
"Maintenance Through Modern Lubricants, Reduction of"—By J. R. WICOFF, April, 1961, Page 121.
"Management Planning, A New Horizon in"—By H. C. McCLELLAN, April, 1961, Page 148.
"Material and Design Defects in Forged Steel Rolls"—By A. A. BRADD, January, 1961, Page 85.
"Merchant Bar and Rod Mill, Fundidora de Fierro y Acero de Monterrey, Mexico Reports on Their New Combination"—By A. FERNANDEZ and B. R. WIBLE, March, 1961, Page 89.
"Merchant Bar Mills, Retaining Flexibility in the Design of Mechanized"—By EDWARD C. PETERSON and WILLIAM H. BOBLITZ, July, 1961, Page 67.
"Merchant Mill, Some New Design Features on a Rod and"—By WILLIAM R. LIEBEL, August, 1961, Page 104.
"Midwest Steel Mill, The Influence of Preloading on Economy of Foundations at the New"—By ELIO D'APPOLONIA and L. A. FUGASSI, May, 1961, Page 111.
"Minimizing Pollution from Pickling Lines: Automatic Control of Strip Pickling Bath Composition"—By C. W. SHINGLEDECKER, November, 1961, Page 137.
"Motor—A New AISE Standard, The A-C Mill"—By M. B. ANTRIM, November, 1961, Page 83.

N

"Natural Gas Injection into the Blast Furnace at Lone Star Steel Co."—By FRED W. FARMER and J. C. MORELAND, October, 1961, Page 88.
"New Concepts in Power-Control Rooms for Steel Mill Drive Systems"—By V. E. VERHEYDEN and D. C. NELSON, August, 1961, Page 111.
"New Horizon in Management Planning, A"—By H. C. McCLELLAN, April, 1961, Page 148.
"New Inspection Techniques and Their Effect on the Mill Operator"—By G. P. MICHALOS, September, 1961, Page 163.
"New Methods of Mounting Crane Rails on Overhead Runways"—By A. GORDON SENIOR, July, 1961, Page 132.
"New Techniques in Mill Control Gives Better Hot Strip"—By R. J. MORAN and H. N. SNIVELY, January, 1961, Page 107.
"Next Step in Steel Plant Data Processing, The"—By W. N. SPRAY, December, 1961, Page 113.

O

"Observations of the Steel Industry in India and Japan"—By JOHN L. YOUNG, January, 1961, Page 61.
"Ochiltree Works Modern Electric Furnace, Bar and Merchant Mill, Ceco's"—By W. B. JACOBSEN and LAWRENCE S. BARKER, JR., December, 1961, Page 141.
"Oil-Film Roll Neck Bearings, Test Stand Evaluation of"—By SAMUEL S. RICKLEY and NORMAN A. WILSON, September, 1961, Page 104.
"Oil Mist Lubrication on Anti-Friction Backup Roll Bearings"—By C. W. SOUTHERINGTON, December, 1961, Page 121.
"Open Coil Process to Change Composition and Improve Sheet Steels, Use of"—By J. A. BAUSCHER, May, 1961, Page 73.
"Open Hearth, Dealing with Fumes from the"—By W. STRAUSS, June, 1961, Page 98.
"Open Hearth Furnace Roof, Installing a Sprung Basic"—By K. D. BARTELS, June, 1961, Page 120.
"Open Hearth Furnaces, Techniques in Rebuilding"—By CARL F. BESSENT, September, 1961, Page 133.
"Open Hearth Improvements for Optimum Results Using Oxy-Fuel Burners and Oxygen Lances"—By WILLIAM A. VOGT, June, 1961, Page 87.
"Open Hearth Precipitators with Oxygen Lances, Design and Operation of"—By A. T. PARADIS, June, 1961, Page 124.
"Open Hearth Production, Cupola Metal Increases"—By WILT H. STEINHEIDER, July, 1961, Page 108.
"Open Hearth Shop, Symposium on Fairless Works"—By W. E. BRANDT, K. D. BARTELS and A. T. PARADIS, June, 1961, Page 116.
"Orcarb Electric Furnace Process for the Direct Reduction of Iron Ore"—By W. R. BRADDOCK, April, 1961, Page 123.
"Ore, Orcarb Electric Furnace Process for the Direct Reduction of Iron"—By W. R. BRADDOCK, April, 1961, Page 123.
"Ores Furthers Automation of the Blast Furnace, Agglomeration of Iron"—By DR. M. J. GREAVES, March, 1961, Page 119.
"Oxy-Fuel Burners and Oxygen Lances, Open Hearth Improvements for Optimum Results Using"—By WILLIAM A. VOGT, June, 1961, Page 87.
"Oxy-Fuel Processes Increase Steelmaking Rates"—By E. F. KURZINSKI and R. D. JONES, February, 1961, Page 67.
"Oxygen Analyzer-Controller, Experience with the"—By WILLIAM G. ENDER, November, 1961, Page 168.
"Oxygen Converter for the Nonintegrated Steel Plant, Electric Furnace or Cupola, Basic"—By D. A. SUTCH and H. C. MANLEY, July, 1961 Page 101.
"Oxygen Converters? Electric Furnaces or Cupola-Basic"—By J. M., BERTRAM, December, 1961, Page 137.
"Oxygen Lance Installation and Practice"—By W. E. BRANDT, June, 1961, Page 116.
"Oxygen Lances, Design and Operation of Open Hearth Precipitators with"—By A. T. PARADIS, June, 1961, Page 124.
"Oxygen Lances, Open Hearth Improvements for Optimum Results Using Oxy-Fuel Burners and"—By WILLIAM A. VOGT, June, 1961, Page 87.
"Oxygen Shop, Colorado Fuel and Iron's Basic"—By GEORGE GROSVENOR, JULY, 1961, Page 91.
"Oxygen Steel Process Gases, The Venturi Scrubber for Cleaning"—By HOWARD P. WILLETT and DANIEL E. PIKE, July, 1961, Page 126.
"Oxygen Steelmaking in the Ajax Furnace of the Appleby-Frodingham Steel Co."—By ALBERT JACKSON, April, 1961, Page 67.
"Oxygen Steelmaking Process, Refractory Maintenance in Basic"—By H. C. WILLENBROCK, JR., March, 1961, Page 75.

P

"Pelletizing, Iron Ore Agglomeration—Sintering and"—By ALAN ENGLISH, March, 1961, Page 113.
"Pickling Lines: Automatic Control of Strip Pickling Bath Composition, Minimizing Pollution from"—By C. W. SHINGLEDECKER, November, 1961, Page 137.
"Pictorial Review—AISE Annual Convention," October, 1961, Page 162.
"Pictorial Roundup—AISE Spring Meeting," May, 1961, Page 106.
"Pictorial Roundup—AISE Western Meeting," April, 1961, Page 146.
"Pipe Coatings-Methods and Problems, Applying Clear, Mill Type"—By DONALD A. GOLBEY, September, 1961, Page 116.
"Plate Mill: Algoma's 46-In. Blooming and"—By J. L. LAIDLAW and J. H. WALSHAW, January, 1961, Page 67.
"Plate, The Rolling of Ultra-Thin Tin"—By MORRIS D. STONE, June, 1961, Page 67.
"Pneumatic and Hydraulic Material Handling Systems in the Steel Industry"—By L. E. MYLTING, March, 1961, Page 107.
"Power-Control Rooms for Steel Mill Drive Systems, New Concepts in"—By V. E. VERHEYDEN and D. C. NELSON, August, 1961, Page 111.
"Power Data, How to Get and Use Rolling Mill"—By A. J. WINCHESTER, July, 1961, Page 92.

"Power Distribution System of an Integrated Steel Plant, The"—By DONALD STEWART, JR., December, 1961, Page 150.
"Precipitators with Oxygen Lances, Design and Operation of Open Hearth"—By A. T. PARADIS, June, 1961, Page 124.
"Preloading on Economy of Foundations at the New Midwest Steel Mill, The Influence of"—By ELIO D'APPOLONIA and L. A. FUGASSI, May, 1961, Page 111.
"President's Message, The," January, 1961, Page 78.
"Pressurization of Idle Coke Ovens"—By A. D. SHATTUCK, March, 1961, Page 83.
"Processing Equipment for Stainless Steel Bright Annealing"—By S. FRIEDLANDER, May, 1961, Page 85.
"Processing Lines, Data Accumulation for Metal"—By H. S. FEGELY, March, 1961, Page 140.
"Production and Uses of Aluminized Steel, The"—By JOHN D. SPROWL, October, 1961, Page 96.
"Production Aspects of the Dwight-Lloyd McWane Ironmaking Process"—By HAROLD E. ROWEN and C. D. THOMPSON, June, 1961, Page 90.
"Productivity, The Influence of Capital On"—By WILLIAM T. HOGAN, S.J., December, 1961, Page 93.
"Program—1961 AISE Annual Convention," September, 1961, Page 148.
"Program—AISE Spring Conference," March, 1961, Page 97.
"Program—AISE Western Meeting," February, 1961, Page 74.

R

"Radiant Comfort Heating, Gas-Fired"—By J. N. EVANS and V. A. URSCHEL, November, 1961, Page 130.
"Rails on Overhead Runways, New Methods of Mounting Crane"—By A. GORDON SENIOR, July, 1961, Page 132.
"Recent Developments in Rolling Mill Equipment"—By W. L. STOVER, November, 1961, Page 158.
"Rectifiers for Processing and Auxiliary Drives, The Application of"—By A. S. URANO, September, 1961, Page 177.
"Refractory Maintenance in Basic Oxygen Steelmaking Process"—By H. C. WILLENBROCK, JR., March, 1961, Page 75.
"Refractory Wear in Electric Steel Furnaces, Fundamentals of Heat Distribution and"—By W. E. SCHWABE, December, 1961, Page 104.
"Reduction of Maintenance Through Modern Lubricants"—By J. R. WICOFF, April, 1961, Page 121.
"Regenerators, AISE Manual for Thermal Design of"—By J. W. HLINKA, F. S. PUHR and DR. V. PASCHKIS, August, 1961, Page 59.
"Relay, D-C Differential"—By G. L. MARTHINUSS, November, 1961, Page 164.
"Republic Steel Corp.'s 13-Ft Wire Mesh Facilities at Gadsden"—By C. J. KINSEY, April, 1961, Page 133.
"Republic Steel's 45-In. Slab Mill, Lubrication of"—By W. J. RODENBERGER, March, 1961, Page 78.
"Resins Aid Steel Plant Maintenance, Epoxy"—By ELMER E. BARTHEL, September, 1961, Page 129.
"Retaining Flexibility in the Design of Mechanized Merchant Bar Mills"—By EDWARD C. PETERSON and WILLIAM H. BOBLITZ, July, 1961, Page 67.
"Review of Iron Ore Sintering, A"—By J. H. PORTEUS, May, 1961, Page 144.
"Rod and Merchant Mill, Some New Design Features on a"—By WILLIAM R. LIEBEL, August, 1961, Page 104.
"Rod Checks Blast Furnace Voids, Spring-Loaded"—By W. Z. ZOLKOWSKI, November, 1961, Page 162.
"Rod Mill, Fundidora de Fierro y Acero de Monterrey, Mexico Reports on Their New Combination Merchant Bar and"—By A. FERNANDEZ and B. P. WIBLE, March, 1961, Page 89.
"Roll Neck Bearings, Test Stand Evaluation of Oil-Film"—By SAMUEL S. RICKLEY and NORMAN A. WILSON, September, 1961, Page 104.
"Roll Turning, Super-Lathe for"—By JACK BINNS, October, 1961, Page 117.
"Roll Wear in Finishing Trains of Hot Strip Mills"—By DR. GEORGE SACHS, JAMES V. LATORRE and M. K. CHAKKO, December, 1961, Page 71.
"Roller Bearing Load-Carrying Capacity, A Standardized Method for Rating"—By E. C. DENNÉ, September, 1961, Page 204.
"Rolling Facilities at South Works of U. S. Steel, Automated Structural"—By V. H. LINDBERG and J. E. DUFFY, November, 1961, Page 87.
"Rolling Mill Drive Design, Trends in"—By ROGER JONES and ROYAL HAWLEY, September, 1961, Page 121.
"Rolling Mill Equipment, Recent Developments in"—By W. L. STOVER, November, 1961, Page 158.
"Rolling Mill Power Data, How to Get and Use"—By A. J. WINCHESTER, July, 1961, Page 92.
"Rolling Mills, Factors Involved in the Selection of Electrical Drive Ratings for Metal"—By ALONZO F. KENYON, November, 1961, Page 121.
"Rolling of Ultra-Thin Tin Plate, The"—By MORRIS D. STONE, June, 1961, Page 67.
"Rolls, An Analysis of the Stresses and Deformations in Work"—By CARL F. ZOROWSKI and ALVIN S. WEINSTEIN, April, 1961, Page 99.
"Roof, Installing a Sprung Basic Open Hearth Furnace"—By K. D. BARTELS, June, 1961, Page 120.
"Runways, New Methods of Mounting Crane Rails on Overhead"—By A. GORDON SENIOR, July, 1961, Page 132.

S

"Safety for Steel Plant Electrical Men"—By J. F. TRENNER, September, 1961, Page 144.
"Seamless Tube Mill, Automation in a"—By A. L. ADAMS, August, 1961, Page 118.
"Selecting Electrical Drives for Applications Under 500 HP"—By F. A. WOODBURY, April, 1961, Page 85.
"Sheet Steels, Use of Open Coil Process to Change Composition and Improve"—By J. A. BAUSCHER, May, 1961, Page 73.
"Sinter-Plant Designer Expect? What Maintenance Does the"—By J. H. PORTEUS, September, 1961, Page 131.
"Sintering and Pelletizing, Iron Ore Agglomeration"—By ALAN ENGLISH, March, 1961, Page 113.
"Slabber, Inland's New Automatic"—By E. R. McGAUGHEY and R. J. BEESWY, February, 1961, Page 105.
"Slab Mill, Lubrication of Republic Steel's 45-In."—By W. J. RODENBERGER, March, 1961, Page 78.
"Slabbing Mill Installation at Kaiser Steel's Fontana Plant, Soaking Pit Expansion and"—By MERLE L. GRUVER, July, 1961, Page 112.
"Slabs Heated in Continuous Furnaces, The Transient Temperature Distribution Within"—By DR. A. H. EL-WAZIRI, March, 1961, Page 130.
"Soaking Pit Expansion and Slabbing Mill Installation at Kaiser Steel's Fontana Plant"—By MERLE L. GRUVER, July, 1961, Page 112.
"Solutions to Basic L-D Plant Layout Problems"—By J. W. IRVIN, October, 1961, Page 165.
"Some Concepts of Mill Bearing Lubrication Employing Oil, Plastic Grease and Oil Mist"—By O. G. McCANDLESS, September, 1961, Page 171.
"Some New Design Features on a Rod and Merchant Mill"—By WILLIAM R. LIEBEL, August, 1961, Page 104.
"Soviet Iron and Steel Industry, Automation and Process Control in the"—By W. E. MILLER and R. M. SILLS, June, 1961, Page 78.
"Spring-Loaded Rod Checks Blast Furnace Voids"—By W. Z. ZOLKOWSKI, November, 1961, Page 162.
"Stability of Steel Plant Electrical Systems"—By K. S. KUKA, October, 1961, Page 105.
"Stainless Steel Bright Annealing, Processing Equipment for"—By S. FRIEDLANDER, May, 1961, Page 85.
"Standard No. 1-A—A-C Mill Motor Standards (Tentative) AISE," November, 1961, Page 79.
"Standardized Method for Rating Roller Bearing Load-Carrying Capacity, A"—By E. C. DENNÉ, September, 1961, Page 204.
"Steel Plant Data Processing, The Next Step in"—By W. N. SPRAY, December, 1961, Page 113.
"Steel Production in Latin American Countries"—By GENERAL EDMUNDO DE MACEDO SOARES E SILVA, March, 1961, Page 65.
"Steps Toward Coke Plant Automation"—By N. F. AGNEW, November 1961, Page 107.
"Stockhouse, The Automatic"—By JOHN F. MEISSNER, January, 1961, Page 99.
"Story of Atlantic City, The"—By W. F. PRUDEN, April, 1961, Page 152.
"Stoves, Limitations of Blast Furnace"—By T. R. SCHUERGER and DR. J. C. AGARWAL, October, 1961, Page 143.
"Stretch-Reducing Operations at Colorado Fuel and Iron's Seamless Tube Mill"—By C. C. CRAWFORD, April, 1961, Page 77.
"Strip Mill Electrical System Design Trends, Hot"—By W. M. KRUMMEL, May, 1961, Page 97.
"Strip Mill Loopers, Bar and"—By W. E. KOLLEK, October, 1961, Page 125.
"Strip Mills, Automatic Gage Control on Reversing Cold"—By ALONZO F. KENYON, August, 1961, Page 77.
"Strip Mills, Roll Wear in Finishing Trains of Hot"—By DR. GEORGE SACHS, JAMES V. LATORRE and M. K. CHAKKO, December, 1961, Page 71.
"Strip, New Techniques in Mill Control Gives Better Hot"—By R. J. MORAN and H. N. SNIVELY, January, 1961, Page 107.
"Super-Lathe for Roll Turning"—By JACK BINNS, October, 1961, Page 117.
"Symposium on Fairless Works Open Hearth Shop"—By W. E. BRANDT, K. D. BARTELS and A. T PARADIS, June, 1961, Page 116.

T

"Techniques in Rebuilding Open Hearth Furnaces"—By CARL F. BESSENT, September, 1961, Page 133.
"Tensiometers, Design and Operation of"—By V. O. SOROKIN, May, 1961, Page 130.
"Test Stand Evaluation of Oil-Film Roll Neck Bearings"—By SAMUEL S. RICKLEY and NORMAN A. WILSON, September, 1961, Page 104.
"Transient Temperature Distribution Within Slabs Heated in Continuous Furnaces, The"—By DR. A. H. EL-WAZIRI, March, 1961, Page 130.
"Thermal Design of Regenerators, AISE Manual for"—By J. W. HLINKA, F. S. PUHR and DR. V. PASCHKIS, August, 1961, Page 59.
"Tin Plate, The Rolling of Ultra-Thin"—By MORRIS D. STONE, June, 1961, Page 67.
"Tool Program, Development of a Machine Shop"—By F. J. WOLFE, JR., March, 1961, Page 125.
"Training Program for Key Electrical Maintenance Employees, A"—By DR. JOSEPH S. KOPAS, August, 1961, Page 89.

"Trends in Rolling Mill Drive Design"—By ROGER JONES and ROYAL HAWLEY, September, 1961, Page 121.
"Tube Mill, Automation in a Seamless"—By A. L. ADAMS, August, 1961, Page 118.
"Tube Mill, Stretch-Reducing Operations at Colorado Fuel and Iron's Seamless"—By C. C. CRAWFORD, April, 1961, Page 77.
"Tube Welding Processes, Analysis of Today's"—By NORBERT C. RUBIN, April, 1961, Page 115.

U

"U. S. Steel, Automated Structural Rolling Facilities at South Works of"—By V. H. LINDBERG and J. E. DUFFY, November, 1961, Page 87.
"Use of Castables in Repairing Blast Furnace Linings, The"—By A. EUGENE FREY, August, 1961, Page 120.
"Use of Open Coil Process to Change Composition and Improve Sheet Steels"—By J. A. BAUSCHER, May, 1961, Page 73.
"USSR Iron and Steel Industry, Development of"—By IVAN DENISENKO and ROMAN BELAN, September, 1961, Page 93.
"USSR Iron and Steel Industry—II—Development of"—By IVAN DENISENKO and ROMAN BELAN, December, 1961, Page 156.

V

"Ventilating a Modern Steel Mill Building, Heating and"—By CHARLES H. SMITH, June, 1961, Page 105.
"Venturi Scrubber for Cleaning Oxygen Steel Process Gases, The"—By HOWARD P. WILLETT and DANIEL E. PIKE, July, 1961, Page 126.

W

"Waste Heat Boiler Applications at Inland Steel Co."—By W. M. DOUGLAS, September, 1961, Page 183.
"Welding Processes, Analysis of Today's Tube"—By NORBERT C. RUBIN, April, 1961, Page 115.
"What Maintenance Does the Sinter-Plant Designer Expect?"—By J. H. PORTEUS, September, 1961, Page 131.
"What's New at DOFASCO"—By D. O. DAVIS, April, 1961, Page 126.
"Why Straight Cylindrical Bearings in the Steel Industry"—By PHILIP H. HUTCHINSON, September, 1961, Page 196.
"Wire Mesh Facilities at Gadsden, Republic Steel Corp.'s 13-Ft"—By C. J. KINSEY, April, 1961, Page 133.

"1960 AISE Papers Award Won by J. S. Ride," October, 1961, Page 164.
"1960, Coke and By-Products in," By G. M. GAUDIO and I. E. MADSEN, December, 1961, Page 161.
"1960, Developments in the Iron and Steel Industry During," By I. E. MADSEN, January, 1961, Page 127.
"1961 AISE Officers and Directors," January, 1961, Page 80.
"1961 AISE National Committees," January, 1961, Page 83.

INDEX TO ADVERTISERS

DECEMBER, 1961

A

Aetna-Standard Div., Blaw-Knox Co. 1
Air Preheater Corp., The 257
Air Reduction Sales Co. 188, 189
Ajax Flexible Coupling Co. Inc. 32
Allen-Bradley Co. 217
Alliance Machine Co., The Cover 2
American Manganese Steel Div.,
American Brake Shoe Co. 251
Atlas Car & Mfg. Co. 248
Automatic Transportation Co. Cover 1

B

Bailey Meter Co. 8
Bearings, Inc. 242
Bellows-Valvair 199
Berry Bearing Co. 252
Bethlehem Steel Co. 27, 28, 29, 30
Birdsboro Corp. 196
Blaw-Knox Co.,
Aetna-Standard Div. 1
Foundry & Mill Machinery Div. 215
Bliss Co., E. W. 39
Bristol Co., The 233
Browning & Co., Inc., Victor R. 61
Bucciconi Engineering Co. Inc. 236
Buell Engineering Co., Inc. 216
Bussmann Mfg. Div., McGraw-Edison Co. 168, 169

C

Chemical Construction Corp. 241
Cities Service Oil Co. 180
Cleveland Crane & Engineering Co. 10
Cleveland Tramrail Div.,
Cleveland Crane & Engineering Co. 209, 210
Cone-Drive Gears, Div.,
Michigan Tool Co. 197
Correct-Air Corp. 55
Cutler-Hammer, Inc. 34, 35

D

Davy & United Engineering Co. Ltd. 7
DeLaval Steam Turbine Co. 44, 183
DEMAG 58, 59
Diamond Electronics,
Diamond Power Specialty Corp. 204, 205
Dixie Bearings, Inc. 242
Dodge Mfg. Corp. 62
Dow Industrial Service 64
Dravo Corp. 234, 235
Drever Co. 228
Dynamatic Div., Eaton Mfg. Co. 223

E

Eaton Mfg. Co.,
Dynamic Div. 223
Farval Div. Cover 3
Electric Controller & Manufacturing Div.,
Square D Co. 190, 191, 253
Electro-Alloys Div.,
American Brake Shoe Co. 67
Elwell-Parker Electric Co., The 20

F

Falk Corp., The 65
Farrel-Birmingham Co., Inc. 218
Farval Div., Eaton Mfg. Co. Cover 3
Feller Engineering Co. 63
Femco, Inc. 179
Fly Ash Arrestor Corp. 246

G

Gas Atmospheres, Inc. 247
General Steel Industries, Inc.,
National Roll & Foundry Div. 70
GPE Controls, Inc. 200

H

Hagan Chemicals & Controls, Inc. 24, 25
Hallden Machine Co., The 201
Harbison-Walker Refractories Co. Cover 4, 36, 37
Harnischfeger Corp. 53, 54
Hill Acme Co., The 254
Homestead Valve Mfg. Co. 49
Hyde Park Foundry & Machine Co. 252

I

Iron and Steel Exposition 57

J

Johns-Manville Corp. 42, 43

K

Kaiser Engineers 230
Kerns United Corp. 239

L

Larco, Inc. 229
Link-Belt Co. 195, 256

M

Mackintosh-Hemphill Div.,
E. W. Bliss Co. 207
Manco Mfg. Co. 250
Markal Co. 45
McKay Machine Co., The 12, 13
McLanahan Corp. 208
Mesta Machine Co. 220
Metal Blast, Inc. 192
Minneapolis-Honeywell Regulator Co. 40, 41
Mobil Oil Co. 173, 174, 175
Morgan Construction Co. 46, 47
Morgan Engineering Co., The 68
Murray Co., David W. 60

N

National Carbon Co.,
Union Carbide Corp. 237, 238
National Castings Co. 176
National Electric Coil Div.,
McGraw-Edison Co. 56
National Roll & Foundry Div.,
General Steel Industries, Inc. 70
North American Mfg. Co., The 243

O

Ohio Steel Foundry Co., The 202

P

Panellit, Div. of ISI, Inc. 52
Plibrico Co. 48
Pollock Engineering Co., Inc. 255
Poole Foundry and Machine Co. 270
Post-Glover Electric Co., The 38
Production Machinery Corp. 226

R

Reliance Electric & Engineering Co. 14, 15
Republic Flow Meters Co. 206
Ringsdorff Carbon Corp. 33
Rust Furnace Co. 167

S

SIEMAG Siegener Maschinenbau GMBH 5
Signode Steel Strapping Co. 225
Spectrochemical Laboratories, Inc. 182
Spraying Systems Co. 45
Square D Co., Electric Controller
& Manufacturing Div. 190, 191, 253
Stamco, Inc. 198
Steel Equipment Co. 231
Sticker Industrial Supply Corp. 66
Surface Combustion Div.,
Midland-Ross Corp. 23
Swindell-Dressler Corp. 18, 19

T

Taylor Chain Co., Inc., S. G. 255
Taylor Sons Co., Chas., The 186
Timken Roller Bearing Co., The 170
Tool Steel Gear & Pinion Co., The 184, 185
Torrington Co., The 6
Trabon Engineering Corp. 244

U

Union Carbide Corp.,
National Carbon Co. 237, 238
United Engineering & Foundry Co. 9
United Engineers & Constructors Inc. 240
United States Steel Corp. 17, 50, 51, 219

W

Wagner Electric Corp. 16
Waldron-Hartig Div.,
Midland-Ross Corp. 45
Wean Engineering Co., Inc., The 31
Western Precipitation Div.,
Joy Manufacturing Co. 249
Wichita Clutch Co., Inc. 2
Wilson Engineering Co., Inc., Lee 4

Y

Youngstown Alloy Casting Corp. 232

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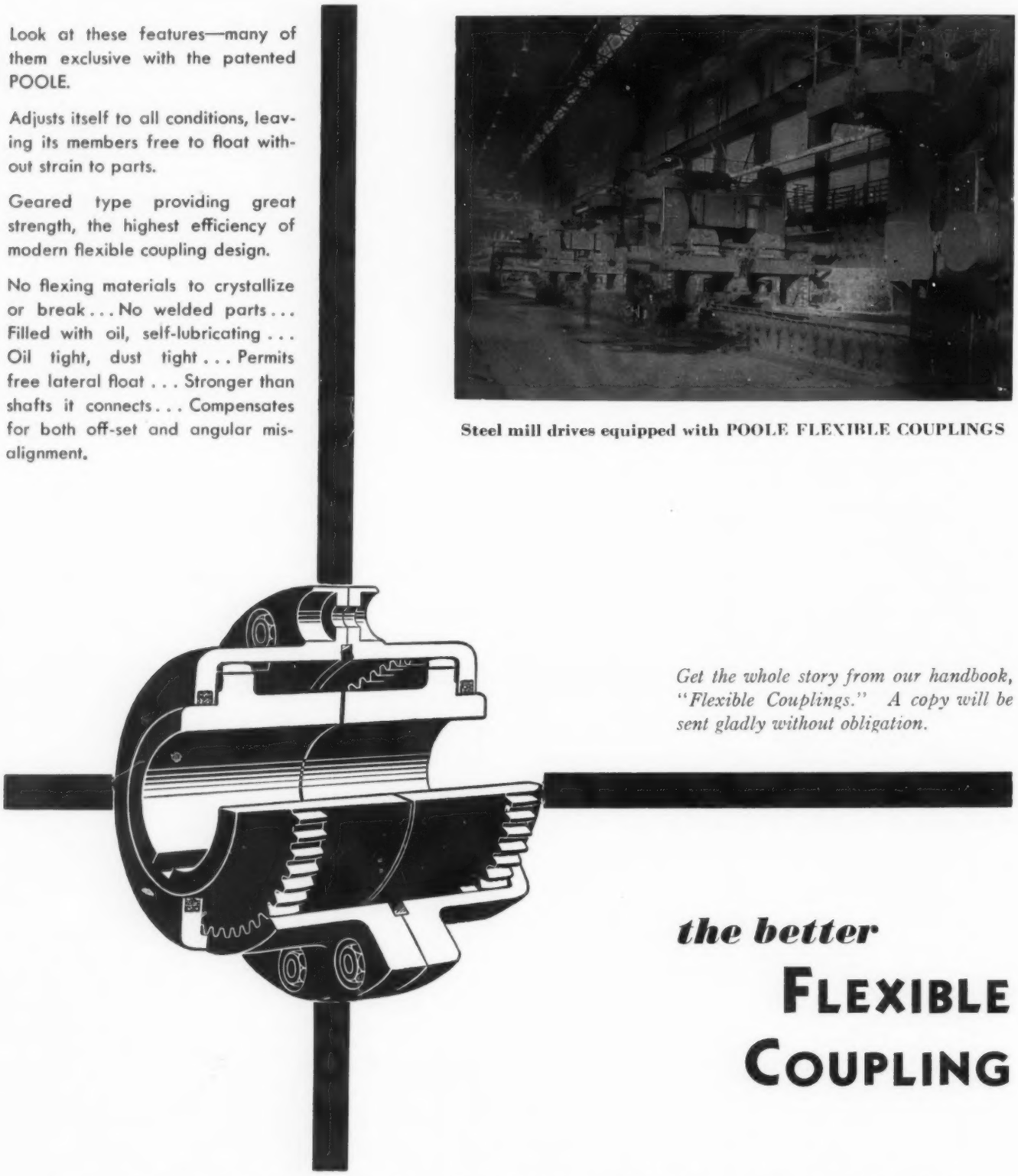

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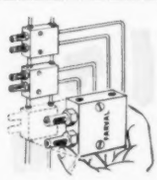

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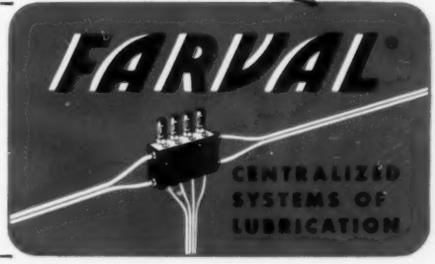

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